

Phylogenomics and systematics of the Gomphaceae with a focus on species diversity in China

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Abstract

Fungi of the family Gomphaceae are ecologically and economically very important. However, due to their morphological complexity and limited phylogenetic information on the taxa in this family, our understanding of its systematics and evolution remains rudimentary. Based on the most recent classification, Gomphaceae included 16 genera with genus *Ramaria* sensu lato being the most species rich. In traditional classification systems, *Ramaria* sensu lato was divided into four subgenera: *Echinoramaria*, *Laeticolora*, *Lentoramaria*, and *Ramaria*. However, recent phylogenetic analysis segregated subgenus *Echinoramaria* into an independent genus *Phaeoclavulina*. Here we explored the phylogenetic relationships among taxa within family Gomphaceae and related genera in other families within the order Gomphales. Phylogenetic analyses were conducted using concatenated sequences of 1025 single-copy orthologs from 66 representative species, along with two-gene (ITS and nrLSU) phylogenetic analyses based on 506 samples. Our data revealed that the previously classified Gomphaceae is a non-monophyletic group and led to the following main changes: (1) Members of traditional subgenus *Lentoramaria* are distant from others in Gomphaceae and this subgenus is separated into five new genera (*Acutiramaria*, *Brachyramaria*, *Gracimaria*, *Lentoramaria* and *Rubellaria*); (2) Some species of subgenus *Laeticolora*, particularly those with pale purple coloration, are transferred to genus *Gomphus*; (3) The remaining members of subgenus *Laeticolora* are merged into genus *Ramaria*, retaining a relatively broad classification of genus *Ramaria*; and (4) *Gautieria* and *Turbinellus* are nested within the genus *Ramaria*, with *Gautieria* clustering with subgenus *Ramaria* and *Turbinellus* grouping with subgenus *Laeticolora*. Overall, five new genera and 113 species including 68 new ones and 13 new combinations were identified and described.

Key words: Gomphaceae, *Ramaria*, Phylogenetic analysis, Phylogenomics, Single-copy orthologous gene

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Introduction

The basidiomycete order Gomphales Jülich (Agaricomycetes) currently comprises three families (Clavariadelphaceae Corner, Gomphaceae Donk, and Lentariaceae Jülich) and 22 genera (Donk 1961; Jülich 1982; Villegas et al. 2005; Hyde et al. 2024). Among the 22 genera formerly placed in Gomphales, some had been tentatively transferred to other orders, such as *Ceratellopsis* Konrad & Maubl. and *Destuntzia* Fogel & Trappe (Fogel & Trappe 1985; Olariaga et al. 2020; Mujic et al. 2024). Additionally, a few genera, including *Araeocoryne* Corner, *Delentaria* Corner, *Terenodon* Maas Geest., *Protogautieria* A.H. Sm., and *Pseudogomphus* R. Heim, *Schildia* Franchi & M. Marchetti, consisted of only one or two

species each in Gomphales but have never been re-reported since their initial classification (Corner 1950, 1970; Eriksson 1954; Maas 1971; Kirk et al. 2008; Franchi & Marchetti 2021). A few of the genera had been placed in different families: *Beenakia* D.A. Reid and *Clavariadelphus* Donk belonged to Clavariadelphaceae, whereas *Gomphocantharellus* L. Fan, Y.Y. Xu, Zhu L. Yang & S.P. Jian, *Hydnocristella* R.H. Petersen, *Kavinia* Pilát, and *Lentaria* Corner were placed in Lentariaceae (Borgarino et al. 2005; Chen et al. 2015; Liu et al. 2017; Huang et al. 2020; Sandoval-Leiva et al. 2022).

Gomphaceae is the most morphologically diverse and species-rich family within Gomphales. However, the current

classification systems for Gomphaceae remain inconsistent Hosaka et al. 2006; Giachini et al. 2010; Zhao 2017; He et al. 2019; Fan et al. 2023). Donk (1961) established Gomphaceae, with *Gomphus* designated as the type genus. Later, he proposed that Gomphaceae included genera *Ramaricium*, *Kavinia*, *Ramaria*, *Clavariadelphus*, *Beenakia*, *Gomphus*, *Chloroneuron* Murrill (now known as *Phaeoclavulina* Brinkmann), and *Gloeocantharellus* (Donk 1964). Recent decades have witnessed considerable advances in the molecular systematics of Gomphales, particularly in resolving intergeneric relationships within Gomphaceae. Early molecular phylogenetic studies based on multi-gene sequences revealed the non-monophyly of some genera in the family, viz., *Gomphus* Pers., *Ramaria* Fr. ex Bonord and *Gloeocantharellus* Singer (Pine et al. 1999; Villegas et al. 1999; Humpert et al. 2001; Hosaka et al. 2006; Giachini et al. 2010). Subsequent phylogenetic analyses employing broader sampling confirmed that Gomphaceae is paraphyletic and comprises several distinct lineages. Several cantharelloid-gomphoid genera such as *Gloeocantharellus*, *Gomphus*, *Turbinellus* Earle, or sequestrate genera like *Gautieria* Vittad, were found to be closely related to ramarioid genus *Ramaria* (Zhao 2017; He et al. 2019; Xu et al. 2022; Fan et al. 2023; Peng et al. 2023). Besides, despite being incongruent with nomenclature rules, a few ramarioid genera such as *Phaeoclavulina*, corticioid *Ramaricium* J. Erikss., as well as cantharelloid-gomphoid genera such as *Luteodorsum* Z.J. Peng, and several lignicolous species of *Ramaria*, have been temporarily assigned to Gomphaceae (Eriksson 1954; Jülich 1982; Pine et al. 1999; Villegas et al. 1999, 2005; Humpert et al. 2001; Giachini 2004a, b; Hosaka et al. 2006; James et al. 2006; Kirk et al. 2008; Bau & Liu 2013; Linhares et al. 2016; Zhao 2017; Ralaiveloarisoa et al. 2021; Li et al. 2022; Xu et al. 2022; Fan et al. 2023; Peng et al. 2023; Vidal et al. 2023; Hyde 2024; Kirk 2024). These findings highlight the need for a renewed and comprehensive taxonomic revision of Gomphaceae.

Ramaria s.l. has the largest number of species within the Gomphaceae, containing more than 300 species described worldwide (Corner 1950; Petersen 1968, 1969; Corner 1970; Petersen 1972, 1974a, b, 1975, 1976; Schild 1978; Petersen 1979, 1981, 1982; Petersen & Zang 1986; Petersen 1987, 1988a, b; Petersen & Scates 1988; Petersen 1989a; Petersen & Watling 1989; Petersen & Zang 1989; Petersen 1990; Schild 1992a, 1998; Petersen & Scates 2000; Zhang et al. 2005; Exeter et al. 2006; Kirk et al. 2008; Christan & Yorou 2009; Petersen et al. 2014; Franchi & Marchetti 2021; Li et al. 2024). The genus, with the type species *R. botrytis* (Pers.) Bourdot, is commonly classified into four subgenera, namely subgen. *Echinoramaria*, *Laeticolora*, *Lentoramaria*, and *Ramaria* (Corner 1950, 1970; Marr & Stuntz 1973; Petersen 1972, 1975, 1981, 1990; Thind and Sharda 1985b; Sharda and Thind 1986; Petersen & Zang 1989). In China, 45 taxa in *Ramaria* have been reported, including seven species in subgen. *Echinoramaria*, two species in subgen. *Lentoramaria*, four species in subgen. *Ramaria*, and 32 species or varieties in subgen. *Laeticolora* (Petersen & Zang 1986, 1989; Petersen 1989b, 1990; Zhang et al. 2005; Li et al. 2024; Zhou et al. 2024). Christan & Hahn (2005) discovered star-shaped crystals in *R. flaccida* (Fr.) Bourdot, and established a new subgenus, namely, *Asteroramaria* Christan & C. Hahn, however, the species was subsequently transferred to *Phaeoclavulina*, with *R. flaccida* now recognized as *Phaeoclavulina flaccida*

(Pine et al. 1999; Villegas et al. 1999; Humpert et al. 2001; (Fr.) Giachini (Giachini et al. 2010). Subgen. *Lentoramaria* mainly includes lignicolous species, whereas the other three subgenera are primarily terrestrial; subgen. *Echinoramaria* is characterized by echinulate basidiospores; *Laeticolora*, the largest of the four, is predominantly composed of species with verrucose basidiospores; and subgen. *Ramaria* is defined by striate basidiospores. Some mycologists classified the four subgenera into different sections or series, for example, Corner (1950, 1970) established several series, while Marchetti and Goya (2001) proposed divisions into various sections. However, these classifications were primarily based on morphological features, lacking molecular support. Molecular phylogenetic studies have demonstrated that *Ramaria* s.l. is not monophyletic in phylogenetic analyses. For instance, subgen. *Echinoramaria* and *Laeticolora* exhibit internal polyphyly or paraphyly. In addition, subgen. *Lentoramaria* occupies a phylogenetic position that is distinctly distant from other subgenera of *Ramaria*, suggesting that *Ramaria* s.l. does not belong to a natural, monophyletic group (Jülich 1982; Hibbett et al. 1997; Pine et al. 1999; Villegas et al. 1999, 2005; Humpert et al. 2001; Giachini 2004; Hosaka et al. 2006; James et al. 2006; Giachini et al. 2010; Gruhn et al. 2017; Zhao 2017; Li et al. 2022; Fan et al. 2023).

In 2010, Giachini et al. reported that *Gomphus* s.l. and spiny-spored *Ramaria* s.l. species (i.e., subgen. *Echinoramaria*) constitute a monophyletic clade, and divided *Gomphus* s.l. into *Gloeocantharellus*, *Gomphus* s.s., *Phaeoclavulina*, and *Turbinellus*. Consequently, *Ramaria* subgen. *Echinoramaria* was removed from *Ramaria*, a decision supported by several mycologists (Franchi & Marchetti 2021; Liu et al. 2022). In addition, *Ramaria* also had a complex taxonomic history. It was once placed in the family Clavariaceae (Persoon 1797a, 1801; Coker 1923; Donk 1933). Based on basidiospores color, Donk (1933) merged *Gomphus* and *Ramaria* in the tribe *Ramariae* within the subfamily Clavarioineae of the family Aphyllophoraceae, in the order Aphyllophorales. Eriksson (1954) proposed that *Ramaricium* J. Erikss. and *Kavinia* Pilát, which have corticioid basidiomata and the basidiospores wall surface is stained with Cotton Blue, were phylogenetically related to *Ramaria*. Corner (1970) disputed Donk's classification of the genus *Ramaria* within the family Gomphaceae and established a new family, Ramariaceae, which included the genera *Kavinia*, *Lentaria*, *Ramaria*, and a newly proposed genus, *Delentaria*. Petersen (1971) disagreed with the establishment of the Ramariaceae family and believed that the above genera should all be retained in Gomphaceae. Subsequently, Petersen (1988b) revised Gomphaceae, with not only the cantharelloid genus *Gomphus* but also the genera *Beenakia*, *Kavinia*, *Ramaria*, *Ramaricium*, and *Ramariopsis*, of which *Ramaria* and *Ramariopsis* were the only clavarioid genera within the family. In recent decades, taxonomists have continued to argue over the taxonomic status of *Ramaria*, the validity of the Ramariaceae, and the genetic composition of the Gomphaceae. Villegas et al. (1999) studied the Gomphaceae s.l. and supported recognition of the Ramariaceae as proposed by Corner and proposed that Gomphales comprises four families: Gomphaceae (including genera *Gomphus* and *Gloeocantharellus*), Beenakiaceae Jülich (including genera *Beenakia*, *Kavinia*, and *Ramaricium*), Ramariaceae (including genus *Ramaria*), and Lentariaceae

Jülich (including genus *Lentaria*). In addition, these authors removed *Delentaria*, *Kavinia*, and *Lentaria* from the Ramariaceae.

As described above, the classification of Gomphaceae has been contentious. Advances in DNA sequencing and genomics have provided new support for its reclassification. The high diversity and complex phylogenetic relationships within fungal groups can be better resolved using phylogenomics analyses, particularly for taxa with uncertain systematic positions. However, phylogenomic analyses targeting Gomphaceae remain scarce, and previous studies have sequenced the genomes of only a few representative species within the order (He et al. 2019). In recent years, several new genera within Gomphales, such as *Gomphocantharellus*, *Luteodorsum* and *Schildia* have been proposed, however, due to the lack of comprehensive phylogenomic data, their exact phylogenetic positions remain unresolved, and they are currently recognized only at the ordinal level (Earle 1909; Giachini 2004, 2010; Franchi & Marchetti 2021; Xu et al. 2022; Fan et al. 2023; Peng et al. 2023).

Based on the above observations, the aims of this study were to: (1) reconstruct the phylogenies of Gomphaceae and *Ramaria* s.l. using concatenated sequences of single-copy orthologous genes (SOGs) and two-gene sequence data; (2) evaluate the phylogenetic relationships of *Ramaria* s.l. with the four related genera: *Gautieria*, *Gloeocantharellus*, *Gomphus*, and *Turbinellus*; and (3) document and characterize both the known and newly discovered Chinese species of Gomphaceae based on morphological and molecular phylogenetic evidence.

Materials and methods

Specimen collection and morphological descriptions

This study included materials from a total of 506 specimens, representing more than 100 species collected in China over the last two decades through field collections, specimen loans, and donations from other collectors. These specimens are housed in the Fungal Herbarium of Hainan Medical University (FHMU), the Mycological Herbarium of Hunan Normal University (MHHNU), the Herbarium of Cryptogams of Kunming Institute of Botany, Chinese Academy of Sciences (HKAS), and the Mycological Herbarium of Kunming Medical University (MHKMU).

The morphological descriptions of new species were based on morphological examinations of fresh and/or dry materials. The color designations followed those of Komerup & Wanscher (Komerup & Wanscher 1978). The notation $[n/m/p]$ was used for descriptions of basidiospore dimensions, representing n basidiospores measured from m basidiomata of p collections. The notation $(a)b-c(d)$ was used for ranges, where “ $b-c$ ” contained a minimum of 90% of the measured values, and extreme values (a and d) were provided in parentheses. The ratio of basidiospore length to width was abbreviated as Q , Q_m was the average Q of all basidiospores measured, and the Q_m value $\pm$ sample standard deviation was provided (Bas 1969). L_m and I_m represented the average length and width of all basidiospores measured, respectively.

The generic names applied in this paper are abbreviated as follows: *Acutiramarina* = “A.”, *Brachyramaria* = “B.”, *Clavariadelphus* = “C.”, *Gautieria* = “Gau.”, *Gloeocantharellus* = “Glo.”, *Gomphus* = “Gom.”, *Gracimaria* = “Gra.”,

Lentoramarina = “L.”, *Phaeoclavulina* = “P.”, *Ramaria* = “R.”, *Rubellaria* = “Rub.”, and *Turbinellus* = “T.”.

DNA extraction, sequencing, and data processing

Whole-genome sequence data generated by next-generation sequencing (NGS) was employed to resolve the phylogeny of Gomphaceae. A total of 70 genomes from Gomphaceae and related genera were included, comprising four retrieved from GenBank and 66 newly generated in this study. Fruiting bodies of 66 selected species were sent to Novogene Co., Ltd. (Beijing) for DNA extraction, library construction, and then sequencing on an Illumina NovaSeq X Plus platform, generating 150 bp paired-end reads for each DNA fragment. Over 5 Gb of sequence data was obtained for each sample. The raw sequence reads were preprocessed using Trimmomatic v0.33 (Bolger et al. 2014), which consisted of trimming adapters and removing low-quality bases. The processed reads were then assembled de novo using SPAdes (Bankevich et al. 2012) with automatic K selection based on read length. Benchmarking Universal Single-Copy Orthologs (BUSCO v5.4.7) was employed to assess the completeness and quality of the genome assemblies (Manni et al. 2021), using the Agaricomycetes OrthoDB v10 database (Zdobnov et al. 2021) as a reference. This database includes 2,898 predefined orthologs (BUSCO genes) derived from 76 samples of Agaricomycetes. These BUSCO genes were used as a query in tBLASTn to search for homologous sequences in our assembled genomes (Gertz et al. 2006). To further confirm the presence of these identified putative BUSCO genes, AUGUSTUS v3.5.0 was run to predict their gene structure (Stanke et al. 2006). HMMER was then used to score these candidate BUSCO genes (Zhang and Wood 2003). Thereafter, BUSCO genes for each sample were retrieved from its corresponding genome. Four genomes that contained fewer than 1900 single-copy BUSCO genes were excluded from the final phylogenomic analyses due to their low quality. In addition, the genome of *R. rubella* (Schaeff.) R.H. Petersen and three outgroup species, *Clathrus columnatus* Bosc, *Hysterangium stoloniferum* Tul. & C. Tul. and *Sphaerobolus stellatus* Tode, were retrieved from GenBank and included in the phylogenomic analyses.

The two-gene (ITS+nrLSU) dataset: The following primer pairs were used for PCR amplification and sequencing of 257 specimens: ITS5 and ITS4 for the internal transcribed spacers 1 and 2 including the 5.8S rDNA gene (ITS) (Vilgalys & Hester 1990; Gardes & Bruns 1993); LR0R and LR5 (Vilgalys & Hester 1990) for the D1–D3 domains of the nuclear 28S rDNA gene (nrLSU). These sequences were analyzed together with those from 248 strains downloaded from GenBank. Alignments were generated separately for each gene fragment using MAFFT v7.310 (Katoh & Standley 2013). The resulting alignments were optimized and trimmed using BioEdit v7.0.9 (Hall 1999), and subsequently concatenated for maximum likelihood (ML) analysis using OFPT v1 (Zeng et al. 2023). *Pterula gracilis* (Desm. & Berk.) Corner and *Pterula echo* D.J. McLaughlin & E.G. McLaughlin in Pterulaceae Corner as outgroup taxa.

Phylogenetic analyses

Two datasets were assembled for this study: Dataset I comprised species in the Gomphaceae and related genera represented by the concatenated SOGs (single-copy

orthologous genes), obtained through whole-genome sequencing, while Dataset II was a multi-copy gene dataset encompassing most species of *Ramaria* s.l. worldwide, incorporating concatenated ITS and nrLSU sequences.

In dataset I (SOGs), 66 specimens representing 66 species of Gomphaceae and related genera were included. The 1090 SOGs shared by more than 95% of samples were aligned using MAFFT v7.505 (Katoh & Standley 2013) under the L-INS-I setting. Alignments with fewer than 100 aligned amino acids were excluded from further phylogenomic analyses. Ambiguous regions in the remaining alignments were then eliminated using Gblocks 0.91b (Talavera & Castresana 2007), with “allowed gap positions” set to “half”, “minimum length of a block: set to “5”, and other default parameters. To investigate the potential effects of sequence biases in the dataset on phylogenomic reconstruction, several related tests were performed using TreSpEx (Struck 2014), which was recently developed to detect possible sequence biases, including long branch attraction (LBA) and saturation. After that, 65 of the 1090 SOGs were excluded from the final analysis. Phylogenomic analyses were then performed based on the remaining 1025 SOGs using both concatenation and coalescence methods. For the concatenation analysis, the SOGs were concatenated using PhyKIT (Steenwyk et al. 2021) and then subjected to the ML analysis using IQ-TREE v2.0-rc1 with automatic detection for the best-fit model with the “-MFP” option (Nguyen et al. 2015). Branch supports were generated with 1,000 UFBoot (ultrafast bootstrap) replicates (Hoang et al. 2018). For the coalescent analysis, sequences with more than 60% gap characters were removed from each SOG to improve the accuracy of individual gene analyses (Sayyari et al. 2017). Individual gene trees were then generated by RAxML v8.2.12 with the GTR+GAMMA model and 1000 rapid bootstrap replicates (Stamatakis, 2014). We next contracted branches with low bootstrap support values ($\leq 30\%$) for these gene trees (Zhang et al. 2017, 2018), and then used these partially multifurcating gene trees to infer the coalescent-based species tree with ASTRAL v5.7.3 (Zhang et al. 2018). The local posterior probabilities (LPP) were used to assess clade support (Sayyari & Mirarab 2016).

Dataset II (ITS/nrLSU) comprised 489 ITS sequences and 406 nrLSU sequences representing a total of 506 specimens belonging to more than 100 species. The total aligned length, including gaps at different positions for different taxa, was 2502 bp, with 1530 bp for ITS and 972 bp for nrLSU. The optimal partition schemes and evolutionary models for dataset II were as follows: ITS (GTR+F+R6) and nrLSU (TIM3e+R5). For taxa described from southwestern China by Petersen & Zang (Petersen & Zang 1986, 1989; Petersen 1990), we were unable to obtain any DNA sequences from their type specimens through PCR amplification and Sanger sequencing. To overcome this problem, next-generation sequencing (NGS) was performed to obtain the target loci. Following the genome skimming approach on a DNBSEQ-T7 platform (BGI, Shenzhen, China), 15 isotype specimens of *Ramaria* s.l. and one specimen of *R. hemirubella* were sequenced. The resulting ITS and nrLSU sequences were extracted from the corresponding genomic data. These sequences were selected and added to Dataset II for phylogenetic analysis.

Results

SOGs phylogenomic analysis of Gomphaceae and related genera

In this study, *Ramaria* sensu lato (*Ramaria* s.l.) is used to include *Ramaria* and the formerly recognized subgen. *Echinoramaria* and *Lentoramaria*, like those treated in previous studies. On the other hand, the term *Ramaria* sensu stricto (*Ramaria*) refers specifically to the newly revised circumscription of the genus in this study.

Dataset I included newly circumscribed *Ramaria* and eight related genera of Gomphaceae, i.e. *Clavariadelphus*, *Gautieria*, *Gloeocantharellus*, *Gomphus*, *Lentaria*, *Luteodorsum*, *Phaeoclavulina*, and *Turbinellus*, along with the outgroup. According to Marr & Stunz (1973), the genus *Ramaria* was traditionally divided into four subgenera: subgen. *Echinoramaria*, *Laeticolora*, *Lentoramaria*, and *Ramaria*. In the phylogenomic analyses generated from the 1025 SOGs, the monophyly of Gomphaceae is strongly supported (BS = 100%, PP = 1), with two well-resolved genera (*Gloeocantharellus* and *Gomphus*) and a major lineage harboring species of *Gautieria*, *Ramaria* and *Turbinellus*. *Gloeocantharellus* formed a highly supported monophyletic clade (BS = 100%, PP = 1), which was a sister group to another strongly supported clade comprising species from *Gautieria*, *Gomphus*, *Turbinellus*, *R.* subgen. *Laeticolora*, *R.* subgen. *Ramaria*. *Gomphus* clustered with some species from *R.* subgen. *Laeticolora* that exhibit purple basidiomata and clamp connections (e.g., *R. violacea*), forming a distinct, well-supported clade (BS = 100%, PP = 1). *Gautieria* was closely related to *R.* subgen. *Ramaria* with strong support (BS = 100%, PP = 1). *Turbinellus* is grouped with a few species of *R.* subgen. *Laeticolora*. Previously defined *Ramaria* species did not form a monophyletic group but rather appeared as a paraphyletic assemblage.

Species of *Ramaria* subgen. *Lentoramaria* were predominantly segregated into five clades. One clade, including *R. concolor* (Corner) R.H. Petersen, *R. paraconcolor* Franchi & M. Marchetti, *R. stricta* (Pers.) Quél., and an unknown species, formed a strongly supported monophyletic group (BS = 100%, PP = 1). The remaining five clades each contained one or two species: *R. comitis* Schild and *R. rainierensis* Marr & D.E. Stuntz grouped together, while *R. apiculata* (Fr.) Donk, *R. gracilis* Quél. *R. rubella*, and *R. suecica* (Fr.) Donk were each placed in separate clades.

Species within subgen. *Echinoramaria* formed a strongly supported clade (BS = 100%, PP = 1) that is distinct from Gomphaceae, corroborating the viewpoint of Giachini et al. (2010) and Hyde et al. (2024), to which the name *Phaeoclavulina* would apply at the generic rank.

Based on SOGs phylogenomic analysis, taxonomic conclusions for Gomphaceae are as follows: (1) Gomphaceae comprises *Gloeocantharellus*, a redefined *Gomphus* (including species formerly in *Gomphus* and some ramarioid species from subgen. *Laeticolora*), and a redefined *Ramaria* (including the remaining species of subgen. *Laeticolora* as well as the genera *Gautieria* and *Turbinellus*). (2) The former subgen. *Echinoramaria* and *Lentoramaria* are excluded from Gomphaceae. The subgen. *Echinoramaria* corresponds to the genus *Phaeoclavulina*, while the subgen. *Lentoramaria* should be divided into five genera (see taxonomic part).

ITS/nrLSU phylogenetic analysis of gen. *Ramaria* s.l.

Dataset II (ITS/nrLS) comprises more than 100 species (504 strains) of Gomphaceae and two outgroup species, including 256 newly sequenced strains in this study and 248 strains with sequences downloaded from GenBank. A phylogenetic analysis was conducted using the maximum likelihood (ML) method (Fig. 2).

Findings from phylogenetic analyses (Fig. 2) of Chinese specimens are summarized as follows:

Together, 113 species within Gomphaceae are reported in this study, including 68 new species, and 32 known ramarioid species and 13 new combinations. In addition, 20 cantharelloid-gomphoid species are also documented.

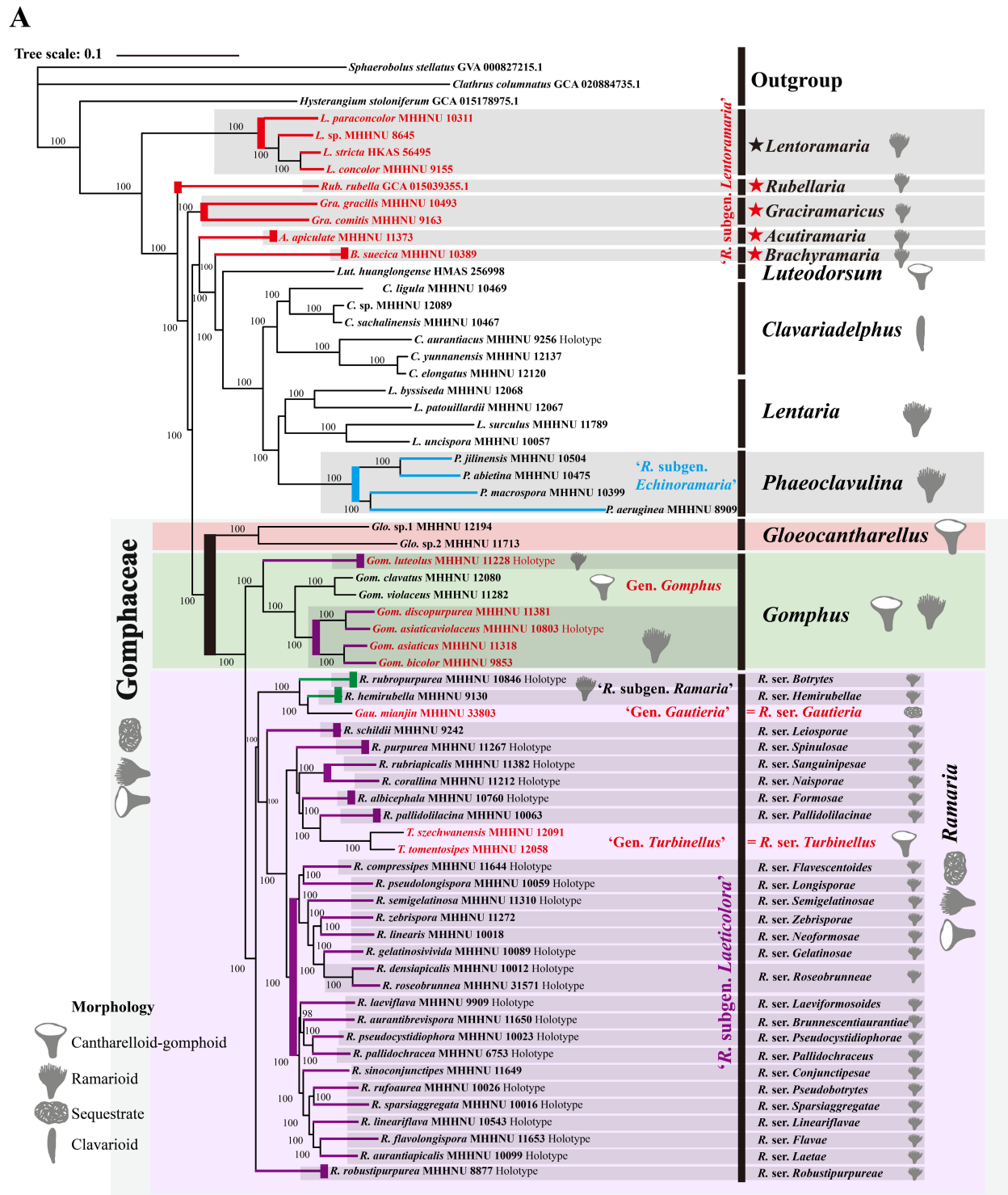


Fig. 1 The concatenation-based phylogenomic analyses of DNA sequences of 1025 single-copy orthologous genes (SOGs) inferred by IQ-TREE (A) and ASTRAL (B). Numbers associated with nodes represent ultrafast bootstrapping support and ASTRAL local posterior probabilities, respectively. Species highlighted in red are those recommended for genus name revision.

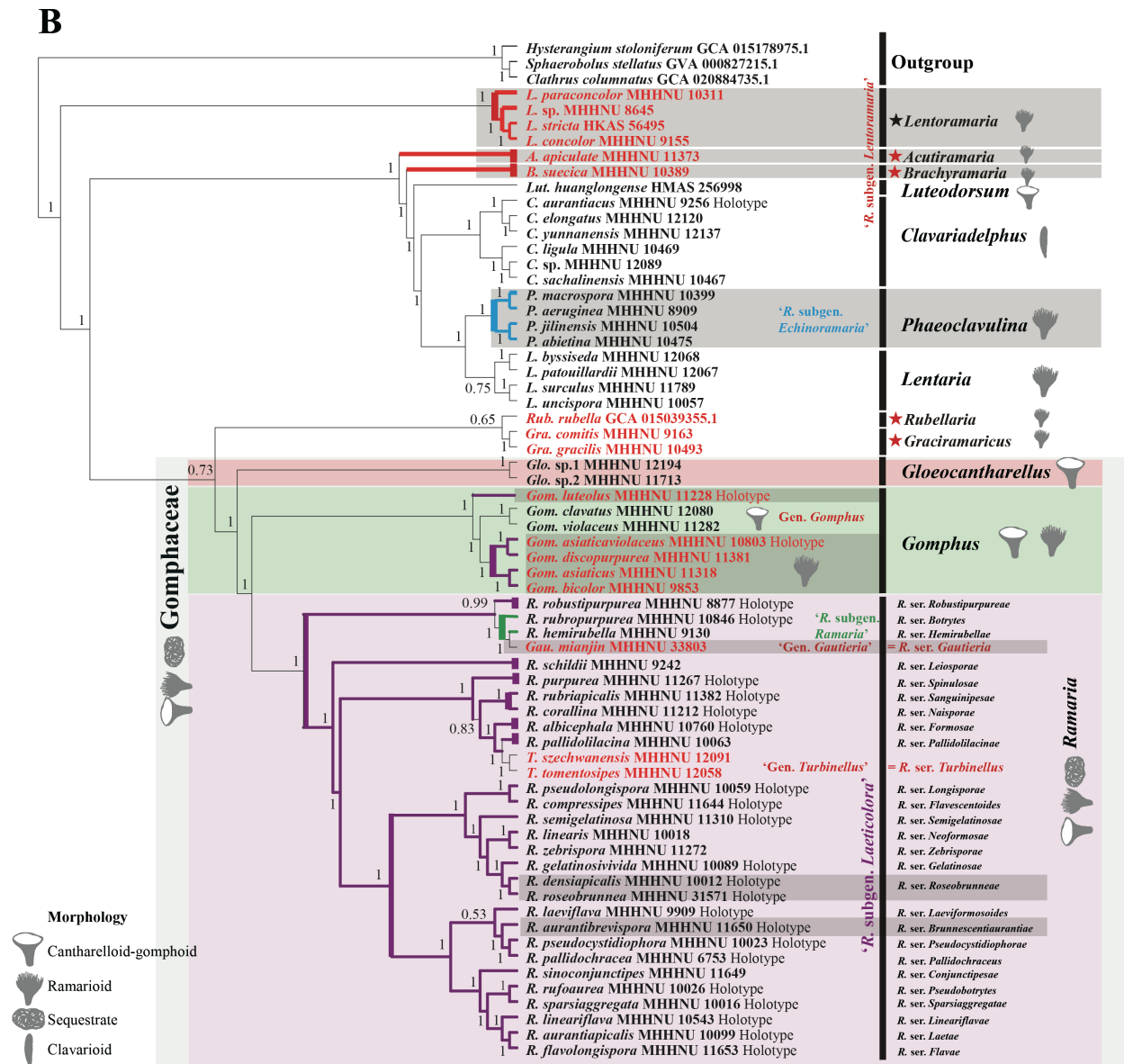


Fig.1 (continued)

Based on SOGs and two-gene clustering results (Fig. 1 and Fig. 2), the genus name “*Ramaria*” among the published species is distributed across 27 clades. To keep the nomenclatural and taxonomic stability of the ramarioid fungi, we did not replace the genus name *Ramaria* with the earlier established names *Gautieria* or *Gomphus*, nor did we revise the generic status of the cantharelloid-gomphoid genus *Turbinellus*, which is nested within *Ramaria*. Instead, *Gautieria* and *Turbinellus* are provisionally treated as embedded lineages within *Ramaria* s.l. Once the legitimacy of *Ramaria* is resolved, we recommend transferring *Gautieria* and *Turbinellus* to *Ramaria* rather than maintaining them as embedded monophyletic genera.

Taxonomy

Based on SOGs and two-gene molecular, morphological, and ecological data, we present a new classification of Gomphaceae. Additionally, we propose establishing five new

genera which previously classified under *Ramaria* subgen. *Lentoramaria*. The taxa in these five new genera currently have unresolved phylogenetic positions within the order Gomphales. Furthermore, this study explores species diversity within these five new genera and other Gomphaceae taxa documented in China.

I. *Ramaria* subgen. *Lentoramaria* doesn't belong to Gomphaceae and should be divided into five independent genera.

***Acutiramaria* P. Zhang & J. Zhong, gen. nov.**

Mycobank: MB 852898

Etymology: *Acutiramaria*, from *acut* = sharp, signifies that the genus exhibits acute apices.

Diagnosis: Differs from the genus *Lentoramaria* by its basidiomata that are light pinkish ochraceous or creamy yellow, and apices color that is white or concolorous with branches, sometimes greenish.

Type species: *Acutiramaria apiculata* (Fr.) P. Zhang & J. Zhong

Description: 1) basidiomata small to medium sized, on wood or thick leaf litter; 2) arising from a basal mat of mycelium or easily observable rhizomorphic strands; 3) light pinkish ochraceous or creamy yellow when young, and becoming deeper ochraceous brown, vinaceous-cinnamon or rufescent alutaceous from the base upward at maturity; 4) hyphae thin walled or thick walled, monomitic; 5) basidia base with clamps; 5) basidiospores roughened in profile.

Ecology: Gregarious on rotting deciduous and coniferous wood; primarily in summer and autumn.

Distribution: At least in Asia, north Europe, and North America.

Commentary: Based on two-gene phylogenetic analyses, species of subgen. *Lentoramaria* within the genus *Ramaria* were predominantly segregated into six independent genera (Fig. 2). Additionally, *A. apiculata* and its varieties formed a high supported clade distinct from the Gomphaceae. Furthermore, species within the genus sometimes exhibit greenish hues and consistently lack skeletal hyphae, distinguishing them from the genus *Lentoramaria*. These findings support the proposal of a new genus.

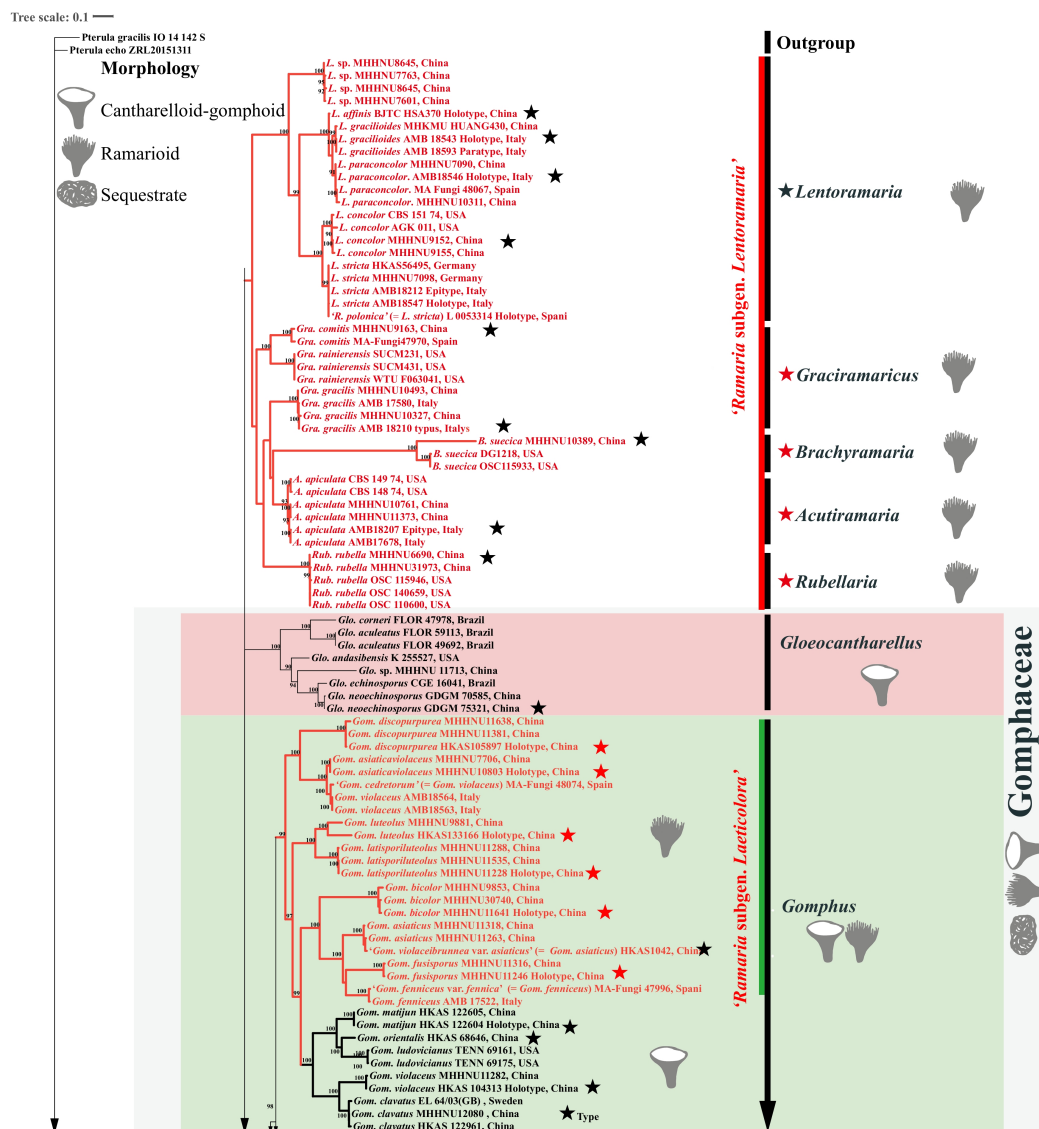


Fig. 2 The maximum likelihood phylogenetic tree of Gomphaceae inferred using the combined ITS+nrLSU sequences to aid species recognition within the family. ML bootstrap values >90% are displayed at relevant nodes. A black star marks a holotype, isotype, epitype, or a specimen representing a known Chinese *Ramaria* species, including new combinations. A red star indicates the holotype of a newly identified *Ramaria* species from China. Every sample of a species without a star indicates that the species was not originally described from China. Species names highlighted in red represent either cantharelloid gomphoid taxa within the Gomphaceae or species whose genus or species names require revision.

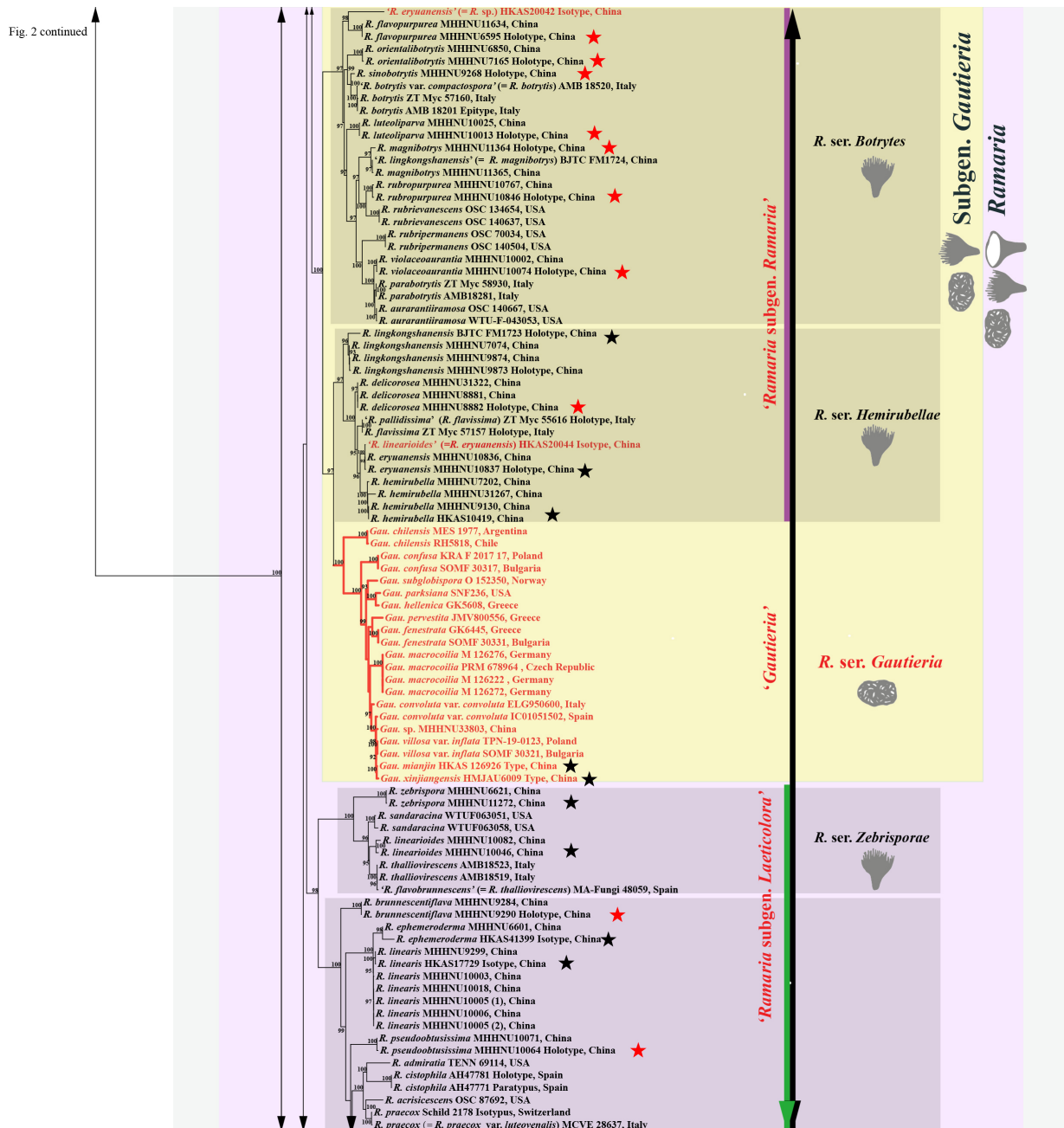


Fig. 2 (continued)

MycoBank: MB 853040

Basionym: *Clavaria apiculata* Fr., Syst. mycol. 1: 470 (1821). [= *Clavaria apiculata* Fr., Observ. mycol. (Havniae) 2: 288 (1818)]
 ≡ *Clavariella apiculata* (Fr.) P. Karst., Revue mycol., Toulouse 3 (no. 9): 21 (1881)
 = *Clavaria densissima* Peck, Bull. Torrey bot. Club 30: 98 (1903)
 = *Clavaria tsugina* Peck, Bull. N.Y. St. Mus. 67: 27 (1903)
 = *Clavaria dendroidea* var. *compacta* Bourdot & Galzin, Hyménomyc. de France (Sceaux): 98 (1928) [1927]
 ≡ *Ramaria apiculata* (Fr.) Donk, Bibliotheca Mycol. 21: 105 (1933)
 = *Ramaria apiculata* var. *compacta* (Bourdot & Galzin)

= *Ramaria apiculata* f. *compacta* (Bourdot & Galzin) R.H. Petersen, Biblthca Mycol. 43: 51 (1975)

Etymology: “*apiculata*” signifies the presence of acute apices.

Diagnosis: Differs from other known species by its light pinkish ochraceous or creamy yellow basidiomata, and apices whitish then paler concolorous, sometimes greenish.

Epitype: Franchi & Marchetti, Riv. Micol. 60(1): 43. 2017; Europe, Italy, Vpitenò, AMB 18207 (GenBank Acc. No.: ITS = MF288927, nrLSU = MF288935).

Description: *Basidiomata* 3–11 x 3–9 cm stipitate or branched from the base, repeatedly branched, arising from a

basal mat and rhizomorphic strands. *Rhizomorphic strands* white, extensive, ill-defined, often minutely webbed, mealy; basal mat not extensive, off-white, felty to minutely strigose, often mealy. *Stipe* (when present) and major branches pallid ochraceous tan when very young, maturing to cinnamon brown to cinnamon tan, slowly changing to chocolate brown when bruised. *Stipe base*, axils and/or apices often pallid green; *Branches* flattened somewhat, erect to ascending; axils flattened; *Apices* acute to sub-palmate, usually flattened, tan to beige.

Basidiospores [30/2/1] (7.2–)7.6–9.8(–10.0) × (3.6–)4.0–5.5(–6.3) μm , L_m = 8.68 μm , l_m = 4.57 μm , Q = (1.59–)1.65–

2.11(–2.32), Q_m = 1.89 $\pm$ 0.18, roughened in profile, ornamentation of ill-defined small, low, cyanophilous warts and small ridges. *Hyphae* of rhizomorphic strands and basal mat monomitic, of two types: a) generative, slender, conspicuously clamped, and b) very rare skeletonized generative segments 3–4.5 μm diam, equal, arising and ending in clamps, opalescent under phase contrast.

Ecology: Usually gregarious in a forest with *Picea* or *Abies* with lignicolous or humicolous habit; primarily in summer and autumn.

Distribution: At least in Asia, north Europe, and North America (Petersen 1975; Wu 1987; Franchi & Marchetti 2021).

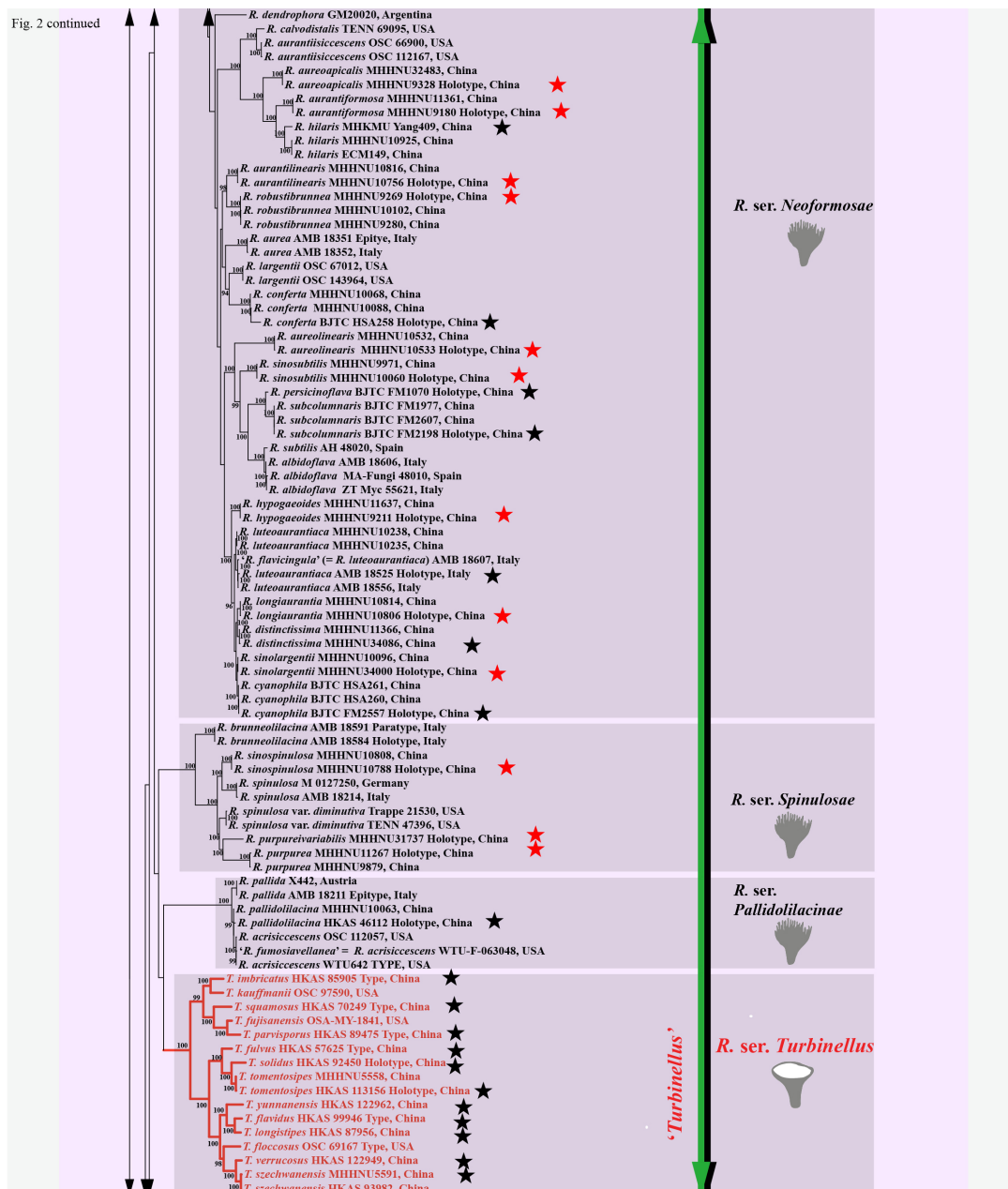


Fig. 2 (continued)

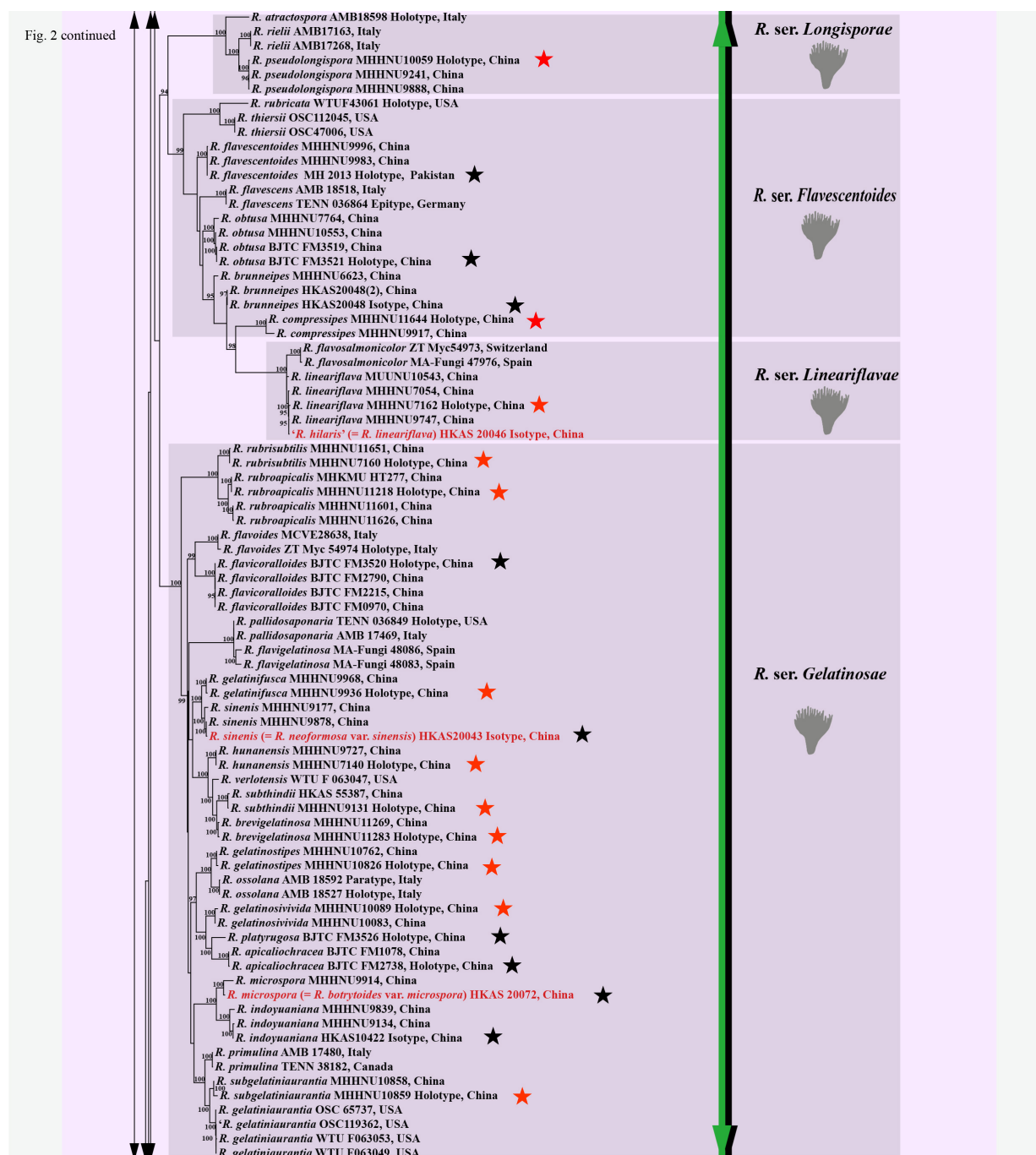


Fig. 2 (continued)

Additional specimens examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 5 September 2021, P. Zhang 4261 (MHHNU 10761); same city, Pusharong Township, Yuelianghu, in mixed forest, altitude 3600 m, 25 August 2017, P. Zhang 2761 (MHHNU 9261), P. Zhang 2766 (MHHNU 9266). YUNNAN PROVINCE: Shangri-La City, Pudacuo, in the forest with *Quercus semecarpifolia*, altitude 3400 m, 14 August 2018, P. Zhang 3394 (MHHNU 9894); same location, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3422 (MHHNU 9922), same city, Xiaozhongdian Township, Tuanjie Village, Qianhu Mountain, in mixed forest,

altitude 3450 m, 2 September 2022, P. Zhang 4870 (MHHNU 11370), P. Zhang 4873 (MHHNU 11373); same city, Deqin County, Baima Snow Mountain Nature Reserve, in *Picea* forest, altitude 3750 m, 17 August 2018, P. Zhang 3447 (MHHNU 9947), P. Zhang 3450 (MHHNU 9950); same location, 18 August 2018, P. Zhang 3459 (MHHNU 9959), P. Zhang 3460 (MHHNU 9960), P. Zhang 3462 (MHHNU 9962).

Commentary: Petersen (1975) reported frequent encounters of this species in northern North America (and at higher altitudes southward) and northern Europe. However, specimens from northern India and Himalayas exhibit a more pallid coloration and a hint of violet or purplish shades. Fries (1821) observed that the greenish branch tips were not

consistently present. Due to historical misinterpretations of the taxon, collections lacking greenish coloration were often misidentified as *R. stricta*. In our phylogenetic analysis of Database I and Database II, this species shows a distant relation to true *R. stricta*, and the specimens collected by us lack the greenish tinge at the apices. Additionally, the species shares a close genetic distance with epitype specimens of *A. apiculata* collected in Italy and exhibits morphological characteristics similar to *A. apiculata* var. *brunnea*. The monophyletic clade to which this species belongs is distantly related to the *Ramaria* s.l. and *Lentoramaira*, and its habitat differs from the predominantly terricolous species of *Ramaria* s.l.

***Brachyramaria* P. Zhang & J. Zhong, gen. nov.**

Mycobank: MB 858493

Etymology: *Brachyramaria* is derived from “brachy-” (short) and *Ramaria*, indicating that the genus exhibits short, ramarioid branches.

Diagnosis: *Brachyramaria* is characterized by ivory white to cream basidiomata with short, ramarioid branches.

Type species: *Brachyramaria suecica* (Fr.) P. Zhang & J. Zhong

Description: 1) Basidiomata small, occurring on wood or thick leaf litter. 2) arising from a basal mat of mycelium or easily observable rhizomorphic strands; 3) Basidiomata ivory white to cream, with short, ramarioid branches. 4) hyphae thin walled or thick walled, monomitic; 4) hyphae and basidia base with clamps; 5) basidiospores roughened in profile.

Ecology: Gregarious on rotting coniferous wood; primarily in summer and autumn.

Distribution: Known from Asia and North America.

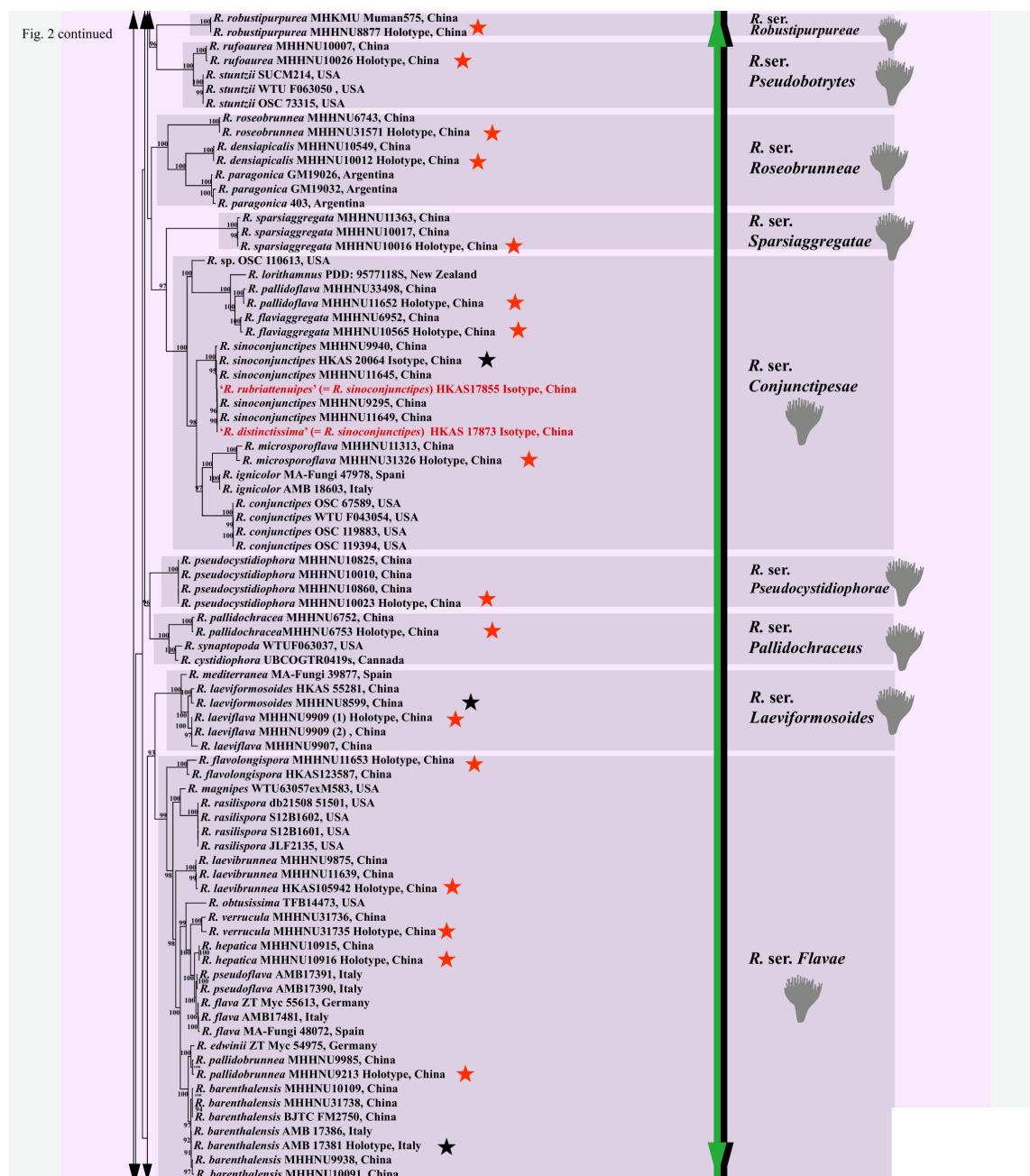


Fig. 2 (continued)

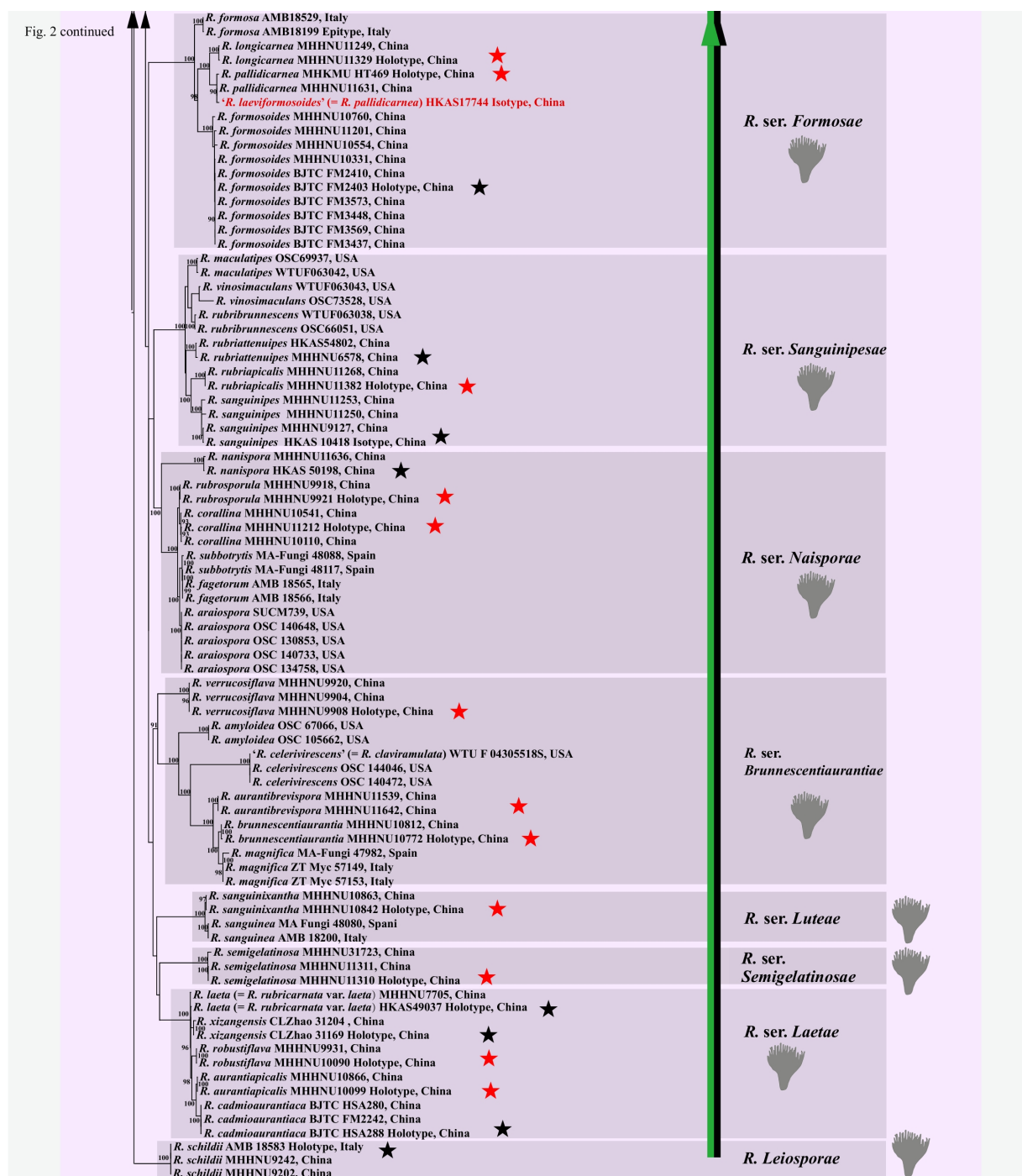


Fig. 2 (continued)

Commentary: Based on SOGs and two-gene phylogenetic analyses, *Brachyramaria* was segregated from Gomphaceae, and *B. suecica* as its sole species. Its distinguishing features—ivory white to cream basidiomata, short, ramarioid branches, and a monomitic hyphal system—clearly differentiate it from other genera in Gomphaceae.

2. *Brachyramaria suecica* (Fr.) P. Zhang & J. Zhong, comb. nov. Fig. 4

Basionym: *Ramaria suecica* (Fr.) Donk, *Rev. Nederl. Homob. Aphyll.* 2: 105 (1933)

Description: Basidiomata 3–6 × 3–5 cm, gregarious or

cespitose on rotting wood. *Rhizomorphic strands* are small, white, and tomentose. *Stipe* 1–3 × 0.5–1 cm, distinct, single, cream to pale yellow. *Major branches* several, erect. *Branches* in 3–5 ranks, erect, short, smooth, strict to lax and open in one form, off-white to cream; internodes gradually shortening upward, V-shaped; *Apices* erect, short and acute, dichotomous to polychotomous, off-white to cream. Odor weakly fragrant; taste negligible.

Basidiospores [60/2/2] (7.8–)8.3–10.4(–11.3) × (3.0–)3.1–4.6(–5.0) μm, $L_m = 9.44$ μm, $l_m = 4.32$ μm, $Q = 2.12–3.00$, $Q_m = 2.48 \pm 0.28$, elongate-ellipsoidal, roughened in profile, thick-walled, and ornamented with cyanophilous warts and small

ridges. *Basidia* 47–60 × 9–12 µm, clavate, thin-walled, hyaline, clamped; sterigmata 4, stout, straight, 6–8 µm. *Hyphae* of rhizomorphic stands and basal mat monomitic, thin-walled,

clamps, which are occasionally swollen and tightly arranged.



Fig. 3 Fresh basidiomata and microscopic features of *A. apiculata*. a–b Fresh basidiomata (a, MHHNU 11373; b, MHHNU 10721); c basidiospores (MHHNU 11373). Scale bars: a–b =2 cm, c =10 µm.

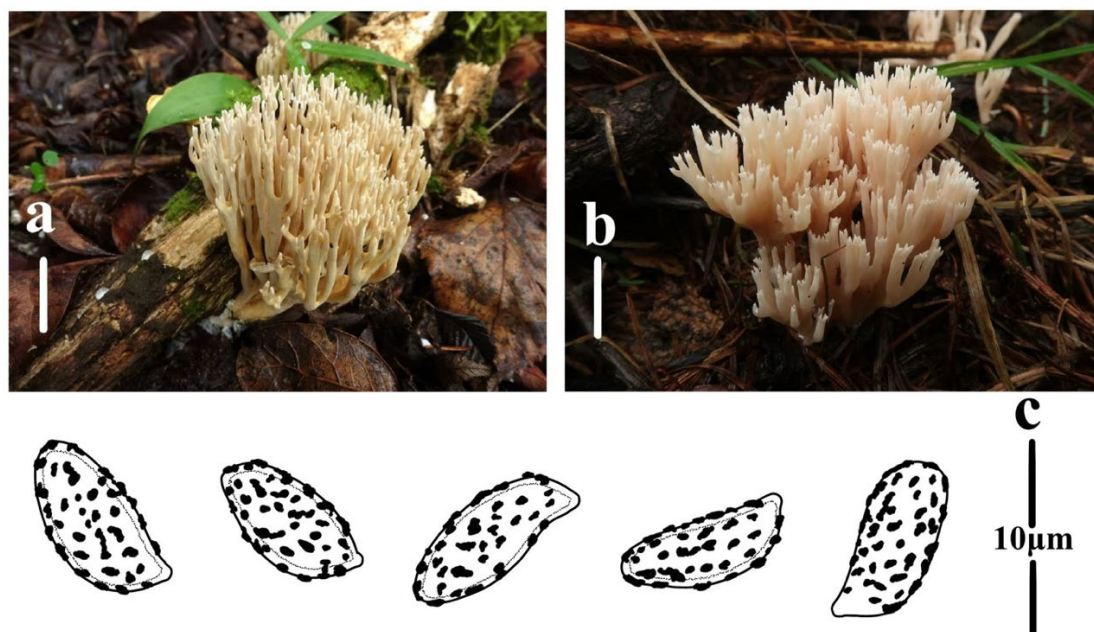


Fig. 4 Fresh basidiomata and microscopic features of *B. suecica*. a–b Fresh basidiomata (a, MHHNU 9981; b, MHHNU 10389); c basidiospores (MHHNU 10389). Scale bars: a–b =2 cm, c =10 µm.

Ecology: In *Quercus* or *Picea* forests or broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from China (Henan, Xinjiang, Xizang, Yunnan) and North America.

Materials examined: HENAN PROVINCE: Luoyang City, Muzaling Primeval Forest, in larch forest, altitude 1800 m, 8

August 2020, P. Zhang 3889(MHHNU 10389), P. Zhang 3897(MHHNU 10397). XINJIANG PROVINCE: Ili, Tekes County, Qiongkushitai, in a *Picea* forest, altitude 2000, 21 August 2019, P. Zhang 3719 (MHHNU 10219), P. Zhang 3724 (MHHNU 10224). XIZANG AUTONOMOUS REGION: Linzhi City, Milin County, Zhaxiraodeng Village, in *Picea* forest, altitude 3040 m,

24 August 2018, P. Zhang 3481 (MHHNU 9981). YUNNAN PROVINCE: Lijiang City, Yulong County, Laojun Mountain, altitude 3000 m, 14 July 2007, Q. Zhao LJ-100 (HKAS 59224).

Commentary: *Brachyramaria suecica* is primarily characterized by its off-white to cream basidiomata, with a white mycelial mat at the base. Unlike other species within subgen. *Lentoramaria*, this species has a monomitic hyphal system with thin-walled hyphae compared to other members of the subgenus.

Gracimaria P. Zhang & J. Zhong, **gen. nov.**

Mycobank: MB 858496

Etymology: *Gracimaria* is derived from *gracilis* (slender) and *Ramaria*, indicating that the genus exhibits slender, ramarioid branches.

Diagnosis: *Gracimaria* is characterized by its slender branches, acute apices and dimitic or monomitic hyphae.

Type species: *Gracimaria gracilis* (Pers.) P. Zhang & J. Zhong

Description: 1) basidiomata small to medium sized, on

wood or thick leaf litter; 2) arising from a basal mat of mycelium or easily observable rhizomorphic strands; 3) slender and ramarioid branches; 4) hyphae thin walled or thick walled, dimitic or monomitic; 4) hyphae and basidia base with clamps; 5) basidiospores roughened in profile.

Ecology: Gregarious on rotting deciduous and coniferous wood; primarily in summer and autumn.

Distribution: At least in Asia, Europe, and North America.

Commentary: Based on SOGs and two-gene phylogenetic analyses, *Gracimaria* was separated from Gomphaceae, consisting only of the two species, *Gra. gracilis* and *Gra. comitis*. It is distinguished by its off-white basidiomata, short and slender branches, and a dimitic hyphal system.

Key to the species of genus *Gracimaria* from China

1. Fruiting bodies off-white to cream, branches sparse, apices acute, spores $L_m < 6 \mu m$ *Gra. gracilis*
1. Fruiting bodies cream to cinnamon, branches dense and parallel, apices acute, spores $L_m > 6 \mu m$ *Gra. comitis*



Fig. 5 Fresh basidiomata of representative species in *Gracimaria*. a–b *Gra. comitis* (a, MHHNU 9163, b, MHHNU 10507); c–d *Gra. gracilis* (c, MHHNU 10493, d, MHHNU 7477). Bar = 2 cm.

3. ***Gracimaria comitis*** (Schild) P. Zhang & J. Zhong, **comb. nov.** Fig. 5 and Fig. 6

Basionym: *Ramaria comitis* Schild, Z. Mykol. 64(1): 56 (1998)

Holotype: ZT Myc 55622 (new identifier for the material deposited by Schild in ZT con n. 2228), Italy, Poggibonsi, Siena Province, Pinuswald, collected on 7 November 1996 by P. Amedeo.

Original Description (Franchi & Marchetti 2021):

Basidiomata 6.5–8.5(–9.5) × 2.5–4.4(–5.0) cm, densely branched. **Stipe** 0.8–1.8 × 1.0–1.3 cm, irregularly cylindrical or somewhat inflated, white at the base, becoming dirty white to creamy upwards, unchanging upon touch. **Branches** 2.5–6 mm thick at the base, repeatedly dichotomous or polychotomous upwards, somewhat divergent or parallel, grayish brown, turning dark purple at age, especially at the apices. **Flesh** dirty white to creamy-white, unchanging color when touch. **Odor** reminiscent of moss or wood, becoming

slightly anise-like with age. Taste slightly acrid or somewhat bitter.

Basidiospores [51/1/1] $6.4\text{--}9.4 \times 3.7\text{--}5.1 \mu\text{m}$, $L_m = 7.9 \mu\text{m}$, $l_m = 4.4 \mu\text{m}$, $Q = 1.6\text{--}2.0$, $Q_m = 1.7$, in mass pale ochraceous, verrucose, cyanophilous. **Basidia** $38\text{--}55 \times 6.3\text{--}8.4 \mu\text{m}$, mostly 4-spored (rarely three-spored), clamps. Hyphal system monomitic, composed of generative hyphae, clamps. **Rhizomorphic strands** are formed by generative hyphae, clamp, slightly thick-walled, smooth.

Ecology: Gregarious on rotting wood in pine forests.

Distribution: Known from Aisa, North America, and northern Europe (Franchi & Marchetti 2021).

Additional materials examined: CHINA, NEI MONGOL AUTONOMOUS REGION: Hulunbuir City, Genhe County,

Delpur, altitude 1050 m, 8 August 2013, P. Zhang 1293 (MHHNU 7793). SICHUAN PROVINCE: Ganzi, Kangding City, Waze Township, in a mixed forest of *Abies* and *Picea*, altitude of 4000 m, 23 August 2017, P. Zhang 2740 (MHHNU 9240). JILIN PROVINCE: YanbianAntu County, Changbai Mountain, Hongsongwang Scenic Area, in mixed forest, altitude 1100 m, 7 August 2017, P. Zhang 2663 (MHHNU 9163); Baishan City, Fusong County, Lushuihe National Forest Park, 26 August 2020, P. Zhang 4007 (MHHNU 10507).

Commentary: The species could be mistaken for *Gra. rainierensis*, but it can be immediately distinguished by the monomitic hyphal and smaller basidiospores ($8.5 \times 5.0 \mu\text{m}$, Marr & Stuntz 1973).



Fig. 6 Basidiospores features of *Gra. comitis* (MHHNU 10507). Bars: a =10 μm .

4. *Gracimaria gracilis* (Pers.) P. Zhang & J. Zhong, comb. nov.
Fig. 5 and Fig. 7

Basionym: *Ramaria gracilis* (Pers.) Quél., Fl. mycol. France (Paris): 463 (1888)

$\equiv$ *Merisma gracile* (Pers.) Spreng., Syst. veg., Edn 16 4(1): 496 (1827)

$\equiv$ *Clavaria gracilis* Pers., Comm. fung. clav. (Lipsiae): 50 (1797)

$\equiv$ *Clavaria fragrantissima* G.F. Atk., Annls mycol. 6(1): 57 (1908)

$\equiv$ *Clavaria stricta* var. *alba* Cotton & Wakef., Trans. Br. mycol. Soc. 6(2): 174 (1919) [1918]

$\equiv$ *Clavariella gracilis* (Pers.) P. Karst., Revue mycol., Toulouse 3(no. 9): 21 (1881)

Lectotype: [illustration in] Persoon, Commentatio de Fungis Clavaeformibus (Leipzig): Tab. 4, Fig. 2, 1797 (Persoon 1797a; Franchi & Marchetti 2021 2017).

Epitype: AMB 18210, Italy, Passo San Pellegrino, Soraga (TN), in mixed forest of *Picea abies* and *Pinus sylvestris*, altitude 1300 m, collected by L. Lami on 13 August 2005, GenBank number: MF288929 (ITS), MF288937 (LSU) (Franchi & Marchetti 2021 2017).

Description: **Basidiomata** $1\text{--}5 \times 3\text{--}4 \text{ cm}$, upward off-white to creamy, base yellow brown. **Stipe** solitary, $0.5\text{--}1 \times 0.3\text{--}0.5 \text{ cm}$, slender, creamy-white becoming darker with age. **Branches** $5\text{--}6$ times, slender, white turning pale yellow-brown when mature, dichotomous, straight or curved, dense, smooth in surfaced; internodes V-shaped, long, parallel. **Apices** acute, off-white, dichotomous, or polychotomous. **Rhizomorphic strands** white. **Flesh** leathery. **Odor** and **taste** are not recorded.

Basidiospores [40/2/2] $5.0\text{--}6.0(\text{--}7.0) \times 3.0\text{--}4.0 \mu\text{m}$, $L_m = 6.49 \mu\text{m}$, $l_m = 4.63 \mu\text{m}$, $Q = (1.25\text{--})1.60\text{--}2.00(\text{--}2.30)$, $Q_m = 1.81$, narrowly ellipsoid, roughened in profile; strong cyanophilous; apiculus prominent. **Basidia** $(24\text{--})30\text{--}43(\text{--}48) \times 7\text{--}9 \mu\text{m}$, clavate, thin-walled, hyaline, clamps at base, 4-spored,

sterigmata $4\text{--}5 \mu\text{m}$ long. **Hyphae** system dimitic, densely interwoven, conspicuously clamped; **Rhizomorphic strands** are formed by generative hyphae, clamps, thick-walled.

Ecology: Gregarious on rotting deciduous and coniferous wood.

Distribution: Known from Aisa and Europe (Franchi & Marchetti 2021).

Additional materials examined: CHINA, HUNAN PROVINCE: Yongzhou City, Dong'an County, altitude of 300 m, Z. H. Chen 30703, 16 September 2010 (MHHNU 30703); Changde City, Shimen County, Hupingshan National Nature Reserve, in mixed forest, altitude 500 m, 8 July 2011, P. Zhang 977 (MHHNU 7477); Yongshun County, Xiaoxi National Nature Reserve, in mixed forest, altitude 900 m, 28 August 2014, P. Zhang 1776 (MHHNU 8276); Zhangjiajie City, Wulingyuan National Forest Park, altitude 800 m, 10 July 2020, Z. H. Chen 32678 (MHHNU 32678), 12 July 2020, Z. H. Chen 32704 (MHHNU 32704), Z. H. Chen 32717 (MHHNU 32717). YUNNAN PROVINCE: Chuxiong, Nanhua County, Yulu Township, in broad-leaved forest, altitude 2000 m, 10 August 2016, P. Zhang 2396 (MHHNU 8896); Lijiang, Yulong County, Yulong Snow Mountain, altitude 3700 m, 26 July 2017, P. Zhang 2793 (MHHNU 9293); Wenshan, Malipo County, Donggan Town, Malibao Village, in broad-leaved forest with Fagaceae, altitude 1700 m, 6 August 2018, P. Zhang 3359 (MHHNU 9859); Chuxiong, Zixi Mountain, in broad-leaved forests, altitude 2200 meters, 25 August 2022, P. Zhang 4798 (MHHNU 11298). JILIN PROVINCE: YanbianAntu County, Changbai Mountain, Hongsongwang Scenic Area, in mixed forest, altitude 1100 m, 7 August 2017, P. Zhang 2665 (MHHNU 9165), 25 August 2019, P. Zhang 3821 (MHHNU 10321), 27 August 2019, P. Zhang 3827 (MHHNU 10327), 11 September 2019, P. Zhang 3829 (MHHNU 10329); Erdaobaihe Town, Changbai Mountain, 25 August 2020, P. Zhang 3993 (MHHNU 10493). HUBEI PROVINCE: Enshi, Hefeng County, Mulinzi Nature Reserve, in mixed forest, altitude 1200 m, 23 September 2020, Z. H. Chen

32544 (MHHNU 32544). GUIZHOU PROVINCE: Longli County, Longjiashan National Forest Park, in coniferous-broadleaf mixed forest, altitude 1300 m, 20 June 2023, P. Zhang 4957 (MHHNU 11457); Leishan County, Leigongshan National Forest Park, in coniferous-broadleaf mixed forest, altitude 1600 m, 21 June 2023, P. Zhang 4962 (MHHNU 11462).

Commentary: This species was first described in 1790 by the naturalist and illustrator James Bolton in *An History of Fungusses Growing About Halifax* (Vol. 3, Tab. 111, Fig. 1). The English author conceived the taxon as a small, unbranched clavarioid species with a dirty white color. Persoon (Persoon 1797a), in his monographic work on simple or branched clavarioid fungi, described *Clavaria gracilis* but, unlike Bolton, associated the species with a branched

species, initially whitish in color, with dimensions similar to those of Bolton's species. Even Fries (Fries 1821) described *Clavaria gracilis*, nom., favoring Persoon's later interpretation. Consequently, with the name, Bolton's concept of taxon fell into obscurity.

Gra. gracilis can be recognized by its small basidiomata, which range from white to creamy, and especially by its anise-like odor. Microscopically, it is distinguished by its dimitic hyphal structure, present both in the context of the stipe and branches, as well as in the mycelium and rhizomorphic strandse.

From a SODs and two-gene perspective, the epitype of *Gra. gracilis* is placed within a monophyletic clade derived from other species.



Fig. 7 Basidiospores features of *Gra. gracilis* (MHHNU 7477). Bars: a = 10 µm.

Lentoramaria (Corner) P. Zhang & J. Zhong, comb. & stat. nov.

Mycobank: MB 852899

Basionym: *Ramaria* subgen. *Lentoramaria* Corner Beih. Nova Hedwigia 33: 239 (1970)

Etymology: The combination of “*lento*”, meaning “flexible”, and the genus name “*ramaria*” signifies that species within this genus exhibit flexible characteristics that differ from those of the genus *Ramaria*.

Diagnosis: Differs from the genus *Acutiramaria* by its dimitic hyphal system and paler basidiomata, and from the genus *Ramaria* s.l. by its lignicolous or humicolous habit, in contrast to the terricolous habit of genus *Ramaria* s.l.

Type species: *Lentoramaria stricta* (Pers.) P. Zhang & J. Zhong (Mycobank: MB 853041)

Description: 1) basidiomata small to medium sized, on wood or thick leaf litter; 2) arising from a basal mat of mycelium or easily observable rhizomorphic strands; 3) white to cream when young, brownish at maturity; 4) hyphae thin walled or thick walled, usually dimitic; 4) hyphae and basidia base with clamps; 5) basidiospores roughened in profile.

Ecology: Gregarious on rotting deciduous and coniferous wood; primarily in summer and autumn.

Distribution: Widespread in Asia, Europe, North America, north Africa (Corner 1950; Petersen 1975; Wu 1987; Zhang 2010; Franchi & Marchetti 2021).

Commentary: In our SODs and two-gene phylogenetic analysis, the species of subgen. *Lentoramaria* (*L. gracilioides*, *L. paraconcolor*, *L. concolor*, *L. stricta*, and *R. sp.*) are excluded from the family Gomphaceae. Additionally, their lignicolous or humicolous habit differs from the terricolous habit of genus *Ramaria* s.l. Therefore, we propose elevating subgen. *Lentoramaria* to genus level.

Key to the species of genus *Lentoramaria* from China

1. Branches sparse, not strict parallel *L. affinis*

1. Branches dense, parallel 2
2. Apices and branches are almost concolorous with each other; branches are medium sized, and contain gloeoplerous hyphae *L. concolor*
2. Without gloeoplerous hyphae 3
3. Apices and branches are almost concolorous; medium sized branches, lignicolous habit *L. paraconcolor*
3. Apices and branches are almost concolorous with each other; branches slender *L. gracilioides*

5. *Lentoramaria affinis* (L. Fan, Y. Li & N. Mao) P. Zhang & J. Zhong, **comb. nov.**

Basionym: *Ramaria affinis* L. Fan, Ying Li & N. Mao, Mycology: 10.1080/21501203.2024.2388910, 10 (Li et al. 2024) Original description in Li et al. (2024).

6. *Lentoramaria concolor* (Corner) P. Zhang & J. Zhong, **comb. nov.** Fig. 8 a–b and Fig. 9

Mycobank: MB 853468

Basionym: *Ramaria stricta* var. *concolor* Corner, Monograph of *Clavaria* and allied Genera, (Annals of Botany Memoirs No. 1): 700 (1950).

≡ *Ramaria concolor* (Corner) R.H. Petersen, *Bibliotheca Mycol.* 43: 54 (1975)

= *Ramaria stricta* var. *orientalis* R.H. Petersen, *Bibliotheca Mycol.* 43: 54 (1975)

= *Ramaria concolor* f. *marrii* R.H. Petersen, *Bibliotheca Mycol.* 43: 62 (1975)

= *Ramaria stricta* var. *laxiramosa* Marr & D.E. Stuntz, *Bibliotheca Mycol.* 43: 140 (1974) [1975]

Diagnosis: Differs from other species of the genus by having apices that are either concolorous with branches or creamy, branches are medium sized and contain gloeoplerous hyphae.

Neotype: The U. S. A., 4 August 1917, illustrated by Coker, 1923.

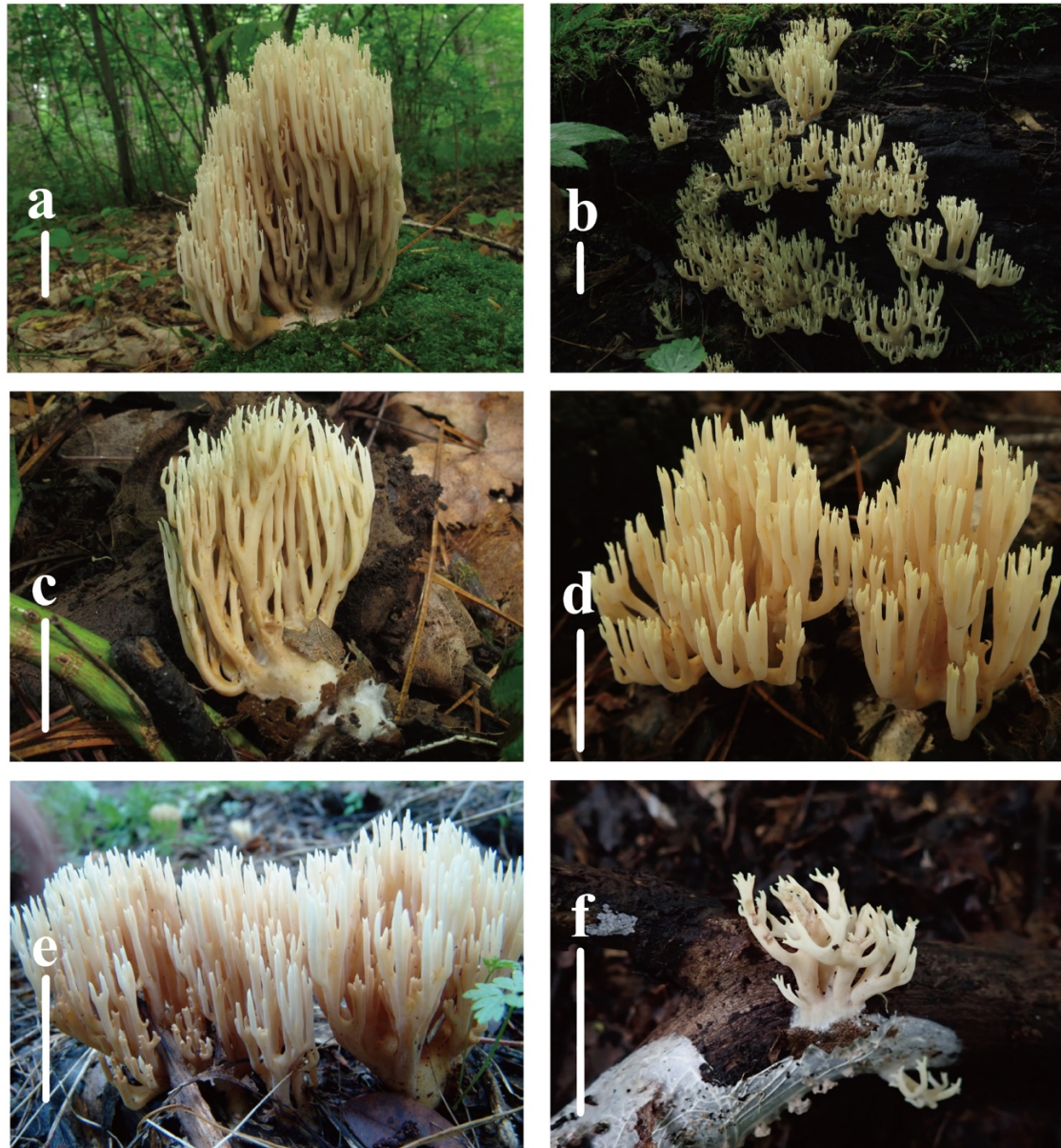


Fig. 8 Fresh basidiomata of representative species in *Lentoramaria*. a–b *L. concolor* (a, MHHNU 9155, b, MHHNU 9152); c–d *L. gracilioides* (c, MHHNU 9154, d, MHHNU 10506); e–f *L. paraconcolor* (e, MHHNU 10311, f, MHHNU 7090). Bars = 2 cm.



Fig. 9 Basidiospores of *L. concolor* (MHHNU 9155). Bars = 10 μ m.

Description: *Basidiomata* 14 × 10 cm, solitary, gregarious or caespitose on rotting wood (either coniferous or deciduous), arising from a small, white, tomentose to felty basal mycelial mat, usually quickly becoming involved in a copious tangle of stout, white, ropy rhizomorphic strands permeating the substrate to an indefinite distance. *Stipe* variable, up to 1.2 cm thick, often branched almost from the base, cinnamon

when fresh and young, becoming either somewhat violaceous or ruddy in age or deep chocolate brown. *Major branches* several, up to 8 mm thick, usually divergent secondarily by the force of the copious branches above, but in one form lax ascending. *Branches* numerous, erect, strict to lax and open in one form, dull ochraceous to tan, becoming dark in age; axils rounded; internodes up to 1.5 cm long below,

gradually shortening; upper branches and apices erect, rounded in cross-section; strict, often somewhat prolonged, dichotomous to polychotomous, some shade of pale tan or ochre-tan, but not yellow or greenish yellow; hymenium usually unilateral, with sterile areas restricted to narrow lines decurrent from axils. Odor strong, of anise or aromatic; taste mildly bitter to bitter, sometimes mildly acid.

Basidiospores [40/4/2] $7.0\text{--}9.0 \times 4.0\text{--}5.0 \mu\text{m}$, $L_m = 7.83 \mu\text{m}$, $l_m = 4.61 \mu\text{m}$, $Q = 1.40\text{--}2.00$, $Q_m = 1.72 \pm 0.18$, roughened in profile; moderately cyanophilous; ornamentation of very obscure, low warts or ridges. **Hyphae** of basal mat and rhizomorphic stands of three types: a) generative, densely interwoven, conspicuously clamped; b) skeletal, thick walled, hyaline, straight, aseptate, arising from a clamp connection but ending blindly; and c) gloeoplerous hyphae $3.5\text{--}4.5 \mu\text{m}$ diam, thin walled.

Ecology: Gregarious on rotting deciduous and coniferous wood, primarily in summer and autumn.

Distribution: At least in Asia, North America, northern and central Europe (Petersen 1975; Wu 1987; Franchi & Marchetti 2021).

Additional materials examined: CHINA, JILIN PROVINCE: YanbianAntu County, Erdaobaihe Town, Changbai Mountain, 25 August 2020, P. Zhang 3986 (MHHNU 10486); same location, 6 August 2017, P. Zhang 2646 (MHHNU 9146), P. Zhang 2647 (MHHNU 947), P. Zhang 2652 (MHHNU 9152); same location, 21 August 2002, P. Zhang 230 (MHHNU 6730); same location, 19 August 2002, P. Zhang 191 (MHHNU 6691), P. Zhang 192 (MHHNU 6692); Baishan City, Fusong County, Lushuihe National Forest Park, 18 August 2002, P. Zhang 184 (MHHNU 6684). HUNAN PROVINCE: Zhangjiajie City, Sangzhi County, Badagongshan National Nature Reserve, 22 October 2014, P. Zhang 1886 (MHHNU 8386).

Commentary: *Lentoramaria concolor* and *L. stricta* are almost identical in microscopic characteristics, odor, taste, and habit, leading to Coker's (1923) mixing up of the two species. *L. stricta* clearly exhibits yellow to greenish yellow apices both in Europe and North America. However, *L. concolor* has branch apices without this characteristic distinctive color, exhibiting a paler color as the branches. According to Petersen (Petersen 1975), the true *L. stricta* produces a somewhat larger fruiting body, but individual specimens cannot be reliably distinguished on this basis alone, especially when dried. Having not observed living material, Corner (1950) proposed Coker's taxon as a variety of *L. stricta* and its concolorous counterpart, with the concolorous form also rarely occurring in Europe. Petersen (Petersen 1975) considered the two-color forms distinct and accepted them at the species level, dividing *L. concolor* into four types.

7. *Lentoramaria gracillioides* (Franchi & M. Marchetti) P. Zhang & J. Zhong, **comb. nov.** Fig. 8 c–d and Fig. 10

Mycobank: MB 853466

Basionym: *Ramaria gracilioides* Franchi & M. Marchetti, Index Fungorum 457: 5 (2020).

Etymology: "*gracilioides*" refers to the species that resemble *Ramaria gracilis*.

Diagnosis: Differs from other species of the genus by its apices and branches, which are almost concolorous with each other, and its dense, slender branches.

Holotype: Europe, Italy, Caldes, 8 September 2007, AMB 18534 (GenBank Acc. No.: ITS = MT055925, nrLSU =

MT053212).

Description: *Basidiomata* $4\text{--}6 \times 2\text{--}2.5 \text{ cm}$, pale yellow or whitish. white rhizomorphic strands or felty basal mycelial mat at base. *Stipe* single, $2\text{--}5 \times 0.5\text{--}0.7 \text{ cm}$, off-white, deeper tones over the time, white or brown tomentose at base, hollow when maturity. *Branches* numerous, erect, strict, becoming dark in age; axils rounded, U-shaped; internodes up to 1.5 cm long below, gradually shortening; upper branches and apices erect, rounded in cross-section; strict, often somewhat prolonged, dichotomous to polychotomous. *Apices* acute and short, pale yellow when young, concolor with branches at age. Odor strong, of anise or aromatic; taste mildly bitter, sometimes mildly acid.

Basidiospores [32/2/1] $(6.5\text{--})6.7\text{--}8.9\text{--}(9.2) \times (3.1\text{--})3.5\text{--}4.9\text{--}(5.1) \mu\text{m}$, $L_m = 7.69 \mu\text{m}$, $l_m = 4.03 \mu\text{m}$, $Q = (1.44\text{--})1.64\text{--}2.23\text{--}(2.28)$, $Q_m = 1.92 \pm 0.21$, roughened in profile; moderately cyanophilous; apiculus prominent, eccentric, truncate, ornamentation of very obscure, low warts or ridges. *Basidia* $40\text{--}50 \times 6\text{--}8 \mu\text{m}$, clavate, clamped. *Hyphae* of basal mat and rhizomorphic stands of three types: a) generative, densely interwoven, conspicuously clamped; b) skeletal, thick walled, hyaline, straight, aseptate, arising from a clamp connection but ending blindly; and c) very rare gloeoplerous hyphae $3.5\text{--}4.5 \mu\text{m}$ diam, thin walled.

Ecology: Gregarious on rotting deciduous and coniferous wood, primarily in summer and autumn.

Distribution: At least in Asia and Europe (Petersen 1975; Wu 1987; Franchi & Marchetti 2021).

Additional materials examined: CHINA, JILIN PROVINCE: YanbianAntu County, Erdaobaihe Town, Changbai Mountain, 6 August 2017, P. Zhang 2654 (MHHNU 9154); Baishan City, Fusong County, Lushuihe National Forest Park, 26 August 2020, P. Zhang 4006 (MHHNU 10506).

Commentary: *Lentoramaria gracilioides* bears a resemblance in fruiting body coloration to *Gra. gracilis*, with both species having dimittic rhizomorphic strands. However, the latter possesses relatively smaller basidiospores measuring $5.0\text{--}6.0\text{--}(7.0) \times 3.0\text{--}4.0 \mu\text{m}$ (as measured in this study).

8. *Lentoramaria paraconcolor* (Franchi & M. Marchetti) P. Zhang & J. Zhong, **comb. nov.** Fig. 8 e–f and Fig. 11

Mycobank: MB 853465

Basionym: *Ramaria paraconcolor* Franchi & M. Marchetti, Index Fungorum 457: 6 (2020)

Etymology: "*paraconcolor*" refers to the species that resembles *Ramaria concolor*.

Diagnosis: Differs from other species of the genus by its lignicolous habit and short basidiospores.

Holotype: Europe, Italy, Bondo, 14 September 2002, AMB 18546 (GenBank Acc. No.: ITS = MT055928, nrLSU = MT053215).

Description: *Basidiomata* $6\text{--}9 \times 2.5\text{--}2.5 \text{ cm}$, ochre-yellow color when young, turn to cinnamon to reddish-brown color at maturity, with injured areas turning purplish brown. white rhizomorphic strands or felty basal mycelial mat at base. *Stipe* single, $2\text{--}5 \times 0.5\text{--}0.7 \text{ cm}$, off-white, deeper tones over the time, white or brown tomentose at base, hollow when maturity. *Branches* numerous, erect, strict, becoming dark in age; axils rounded, U-shaped; internodes up to 1.5 cm long below, gradually shortening; upper branches and apices erect, rounded in cross-section; strict, often somewhat prolonged, dichotomous to polychotomous. *Apices* acute

and short, pale yellow when young, concolor with branches at age. Odor and taste are not recorded.

Basidiospores [32/2/1] (6.2–)6.3–8.4(–8.8) × 3.7–4.9(–5.1) μm , $L_m = 7.30 \mu\text{m}$, $l_m = 4.29 \mu\text{m}$, $Q = (1.37\text{--})1.41\text{--}1.97$ (–2.19), $Q_m = 1.71 \pm 0.19$, roughened in profile; moderately cyanophilous; apiculus prominent, eccentric, truncate, ornamentation of very obscure, low warts or ridges. **Basidia**

20–40 × 6–8 μm , clavate, clamped. **Hyphae** of basal mat and rhizomorphic stands of three types: a) generative, densely interwoven, conspicuously clamped; b) skeletal, thick walled, hyaline, straight, aseptate, arising from a clamp connection but ending blindly; and c) very rare gloeoplerous hyphae 3.5–4.5 μm diam, thin walled.



Fig. 10 Basidiospores of *L. gracilioides* (MHHNU 9154). Scale bars: **a** = 10 μm

Ecology: Gregarious on rotting deciduous and coniferous wood, primarily in summer and autumn.

Distribution: At least in Asia and Europe (Petersen 1975; Wu 1987; Franchi & Marchetti 2021).

Additional material examined: CHINA, JILIN PROVINCE: 23 August 2019, P. Zhang 3811 (MHHNU 10311).

Commentary: In our two-gene phylogenetic analysis, *L. paraconcolor* is related to *L. gracilioedes*. In the description of Franchi & Marchetti (Franchi & Marchetti 2021), *L. paraconcolor* has the narrowest basidiospores width compared to *L. concolor* and *L. gracilioides*. However, we believe the basidiospores of these species are within a similar range and cannot be strictly distinguished. This species grows on decaying wood, and the whiteness of the fruiting body is a more obvious feature.

Rubellaria P. Zhang & J. Zhong, **gen. nov.**

Mycobank: MB 858497

Etymology: *Rubellaria* is derived from *rubella* (reddish or wine-red) and *Ramaria*, indicating that the genus exhibits

wine-red basidiomata with ramarioid and sparse branches.

Diagnosis: *Rubellaria* is characterized by its wine-red basidiomata, ramarioid and sparse branches, and dimitic hyphae.

Type species: *Rubellaria rubella* (Schaeff.) P. Zhang & J. Zhong

Description: 1) Basidiomata small to medium sized, growing on wood, reddish or wine-red, retaining color upon maturity; 2) Stipe not distinct and branches arise directly from the base.; 3) hyphae thin walled or thick walled, monomitic; 4) hyphae and basidia base with clamps; 5) basidiospores roughened in profile.

Ecology: Gregarious on rotting deciduous and coniferous wood; primarily in summer and autumn.

Distribution: At least in Asia, Europe, and North America.

Commentary: Based on SOGs and two-gene phylogenetic analyses, *Rubellaria* was separated from Gomphaceae and consisting only one species, *Rub. rubella*. It is distinguished by its wine-red basidiomata, ramarioid and sparse branches, and dimitic hyphae.

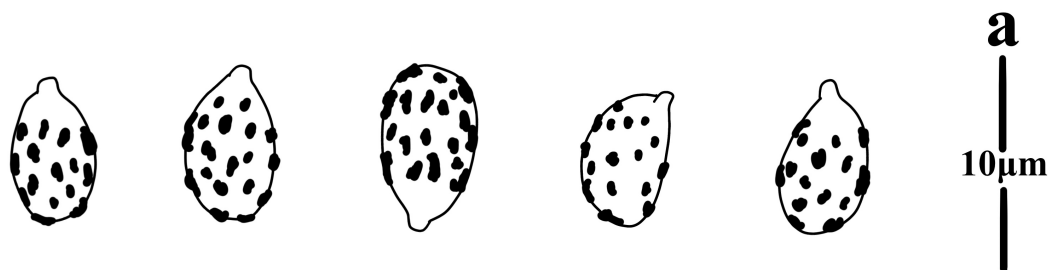


Fig. 11 Basidiospores of *L. paraconcolor* (MHHNU 10311). Scale bars: **a** = 10 μm

9. *Rubellaria rubella* (Schaeff.) P. Zhang & J. Zhong, comb. nov. Fig. 12

Basionym: *Clavaria rubella* Schaeff., Fung. bavar. palat. nasc. (Ratisbonae) 4: 119 (1774)

= *Clavaria acris* Peck, Ann. Rep. Reg. N.Y. St. Mus. 54: 155 (1902) [1901]

= *Ramaria acris* (Peck) Corner, Trans. Br. mycol. Soc. 44(2): 235 (1961)

= *Ramaria rubella* var. *rubella* (Schaeff.) R.H. Petersen, Am. J. Bot. 61(7): 746 (1974)

= *Ramaria rubella* f. *blanda* R.H. Petersen, *Bibliotheca Mycol.* 43: 89 (1975)

= *Ramaria rubella* var. *himalaica* K.S. Thind & Sharda, Proc. Indian Acad. Sci., Pl. Sci. 95(1): 60 (1985)

Etymology: The specific epithet refers to the reddish color of the basidiomata.

Lectotype: [illustration in] Schaeffer, Fungorum qui in Bavaria et Palatinatu circa Ratisbonam nascuntur 2: Tab. 177 fig. 1–2, 1763 (designated by Petersen, 1974: “The excellent illustration which must serve as type for the fungus”).

Description: *Basidiomata* 5–6 × 3–4 cm, wine red color. *Stipe* 1–2 × 0.5–1 cm, solitary or clustered, light brown, later becoming dark brown; flesh leathery. *Main branches* arise directly from the ground. *Branches* 5–6 times, reddish-brown, dichotomous, V-shaped, straight or curved, dense, smooth surface, internodes long, parallel. *Apices* are acute and short, yellowish brown then reddish-brown, dichotomous, or polychotomous to crest-like structure. White rhizomorphic strands at the base, leathery. Odor and taste are not recorded.

Basidiospores [55/2/2] (5.0–)6.0–7.0(–8.0) × 4.0–5.0 µm, $L_m = 6.49$ µm, $l_m = 4.63$ µm, $Q = (1.60–)1.75–2.50$, $Q_m = 1.41 \pm 0.19$, roughened in profile; strong cyanophilous; apiculus prominent, eccentric, truncate, ornamentation of very obscure, low warts or ridges. *Basidia* 40–60 × 7–9 µm µm,

clavate, clamped. *Hyphae* of rhizomorphic stands and basal mat monomitic, thin-walled, clamps, which are occasionally swollen and tightly arranged.

Ecology: Gregarious of rotting deciduous and coniferous wood.

Distribution: Known from Aisa, North America, and northern Europe (Petersen 1975; Wu 1987).

Additional materials examined: CHINA, HUNAN PROVINCE: Zhangjiajie City, Sangzhi County, Badagongshan National Nature Reserve, Tianping Mountain, 27 July 2020, Zuo H. Chen 31953 (MHHNU 31953); same location, 28 July 2020, Zuo H. Chen 31973 (MHHNU 31973).

Commentary: The wine-red color of its basidiomata distinguishes it from other lignicolous or humicolous species. Additionally, its basidiospores are short and wide. The skeletal hyphae in rhizomorphic strands differs from those of *L. stricta* but resembles those of *Gra. gracilis*.

II. *Ramaria* subgen. *Laeticolora* and subgen. *Ramaria* both belong to *Ramaria* in Gomphaceae, with notable species diversity observed in China.

Ramaria Fr. ex Bonord. 1851, Handb. Mykol. 166. nom. cons., non *Ramaria* Holmsk. ex A. Gray, Nat. Arr. Brit. P1. 1: 655, 1821.

= *Ramaria* Holmsk., Beata ruris Otia fung. Dan. 1: 77, 1790

= *Ramaria* Holmsk. ex Raf., Anal. Nat. ou Tabi. Univ.: 211, 1815

= *Ramaria* Holmsk. ex Gray, Nat. arrang. Brit. pi. 1: 655, 1821

= *Clavaria* tribu *Ramaria* Fr., Epicr. Syst. Mycol.: 571, 1838

= *Ramaria* Holmsk. ex Quél., Fl. Mycol. Fr.: 462, 1888

Type species: *Ramaria botrytis* (Pers.) Bourdot, Rev. Sci. Bourb. Centr. Fr. 7: 119–126 (1894)



Fig. 12 Fresh basidiomata and microscopic features of *R. rubella*. a–b Fresh basidiomata (a, MHHNU 31973; b, MHHNU 31953); c basidiospores (MHHNU 31953). Bars: a–b = 2 cm, c = 10 µm, d = 20 µm

Description: 1) Fruiting bodies are terrestrial, small to large size, repeatedly branched, displaying various colors such as red, orange, yellow, purple, and brown, contexts fibrous, fleshy, gelatinous, or leathery. 2) Hymenium turning green of applying 10% ferric sulphate. 3) Basidiospores colored inspect deposit, walls smooth in a few species, mostly verrucose, or striations, basidia mostly 4 sterigmata, basally clamped or not, contextual hyphae monomitic, clamps or not. 4) No cystidia are present. The hyphae of the context are monomitic, have clamps or without clamps, with elongated cells and lacking secondary septa.

The key to the series of *Ramaria*, along with illustrations of 97 species within the genus *Ramaria* is presented as follows.

Key to the series of genus *Ramaria*

1. Basidiospores smooth under electron microscope
.....Ser. *Leiosporae*
1. Basidiospores rough2
2. Basidiospores almost smooth under biological microscope, but with minute ornamentation under electron microscope 3
2. Basidiospores with obvious ornamentation4
3. Basidioma pale colored, not changing color when injured
.....Ser. *Laeviformosoides*
3. Basidioma yellow colored, changing color to brown-yellow or red-brown Ser. *Flavae*
4. Spore ornamentation with distinct stripes5
4. Spore ornamentation in verrucose, or short ridges6
5. Stipes white to light yellow; almost no change in color on bruising; apices flesh-colored to light red Ser. *Hemirubellae*
5. Stipes are stout; changing color on bruising; apices or young branches deep purple-red, orange-purple, or light brown Ser. *Botrytes*
6. Basidioma with purple hue7
6. Basidioma yellow, orange, red, or brown in color, without purple hue9
7. With clamps Ser. *Robustipurpureae*
7. Without clamps8
8. Basidioma overall purple-brownSer. *Spinulosae*
8. Basidioma pale yellow to salmon, only apices have pale purple hue Ser. *Pallidolilacinae*
9. Basidioma are bright orange, red-orange, pink, or red, displaying vivid colors10
9. Basidioma light yellow to yellow, with brownish tones, without pink, red, or orange hues17
10. Stipes, branches and apices almost identical in color 11
10. Stipe, branches or apices in different color, stipe paler in color14
11. Basidioma red-orange to bright orange; flesh white to pale yellow-orange12
11. Basidioma with pinkish, red-orange color; flesh is dark red-orange13
12. Basidioma small to medium sized, with sparse branching; stipe slender to moderately thick, bright orange when young, lightens when maturesSer. *Brunnescentiaurantiae*
12. Basidioma large, with dense branching, yellow to bright orange Ser. *Laetae*
13. Basidioma yellow, pink or bright orange overall, stipe usually single or slender, basidiospores relatively short ($L_m < 11 \mu m$) and not distinct basidiospores ornamentation
..... Ser. *Nanisporae*
13. Basidioma red hint, or context flesh red to orange, stipes usually falsely fasciculate or stout, with distinct basidiospores ornamentationSer. *Pseudobotrytes*
14. Basidioma yellow to salmon, apices yellow to red, changing color to red when injured 15
14. Basidioma pale yellow, not changing color when injured 16
15. Apice yellow to red; basidiospores relatively longer ($L_m > 10 \mu m$) Ser. *Sanguinipesae*
15. Apice yellow; basidiospores relatively shorter ($L_m < 10 \mu m$) Ser. *Luteae*
16. Young branches or apices pink, branches and stipe brown Ser. *Roseobrunneae*
16. Basidioma yellow to salmon, branches slender and apices pink, context of stipe gelatinous, most species without clampsSer. *Gelatinosae*
17. Cespitose habit 18
17. Not cespitose habit 20
18. Basidioma pale yellow to yellow brown, context fleshy Ser. *Pallidochraceae*
18. Basidioma generally small, light yellow to dark yellow, context leathery, tough 19
19. Basidioma deep yellow, context fleshy Ser. *Sparsiaggregatae*
19. Basidioma pale yellow, stipe and branches-tinged pinkSer. *Conjunctipesae*
20. Apices and branches distinctly different colored 21
20. Apices almost concolorous with branches 22
21. Apices off-white, basidioma pale salmon to yellow ochre Ser. *Formosae*
21. Apices yellow, stipe and branches pale yellow to pale salmon, basidiospores small ($L_m < 10 \mu m$) Ser. *Pseudocystidiophorae*
22. Context gelatinous or subgelatinous Ser. *Neoformosae*
22. Context fleshy to fibrous 23
23. Basidioma small to medium sized; stipe single to subfasciculate; branches strict, very sparse; flesh of brancher red to orange Ser. *Semigelatinosae*
23. Flesh of flesh not red to orange color 24
24. Apices acute, branches very slender, small basidiospores ($L_m < 10 \mu m$) Ser. *Linearflavae*
24. Apices rounded 25
25. Obvious change in color when injured 26
25. Not changing or slightly changing color on handling 27
26. Changing color to red-brown, branches slender, stipe stout, basidioma pale yellow to cinnamon, clamped Ser. *Flavescentoides*
26. Changing color to brown, with dense branches, stipe tapering sharply downward to an acute Ser. *Densiapicalisae*
27. Basidiospores relatively longer ($L_m > 11 \mu m$) Ser. *Longisporae*
27. Basidiospores relatively shorter ($L_m < 11 \mu m$) Ser. *Zebrisporae*

Key to the species of ser. *Botrytes* from China

1. Average length of basidiospores $L_m > 18 \mu m$
.....*R. sinobotrytis*
1. Average length of basidiospores $L_m < 18 \mu m$ 2
2. Average length of basidiospores $L_m < 12 \mu m$ 3
2. Average length of basidiospores $12 \mu m < L_m < 18 \mu m$.. 4
3. Basidioma light color, creamy, distributed in southwestern China *R. luteoliparva*

3. Basidioma purple-red, turning wine-red on bruising, distributed in central China *R. orientolibotrytis*
4. Stipe not changing color on bruising 5
4. Stipe changing color on bruising 6
5. Apices are darker in color, purplish-red with orange tones *R. violaceoaurantia*
5. Young branches and apices are purplish-red; creamy on maturity *R. magnibotrys*
6. Stipes changing color to lemon yellow on bruising *R. flavopurpurea*
6. Stipes changing color to purple-red color on bruising *R. rubropurpurea*

Key to the species of ser. *Brunnescentiaurantieae* from China

1. Basidioma red-orange; stipe changing color to reddish-brown on bruising *R. brunnescentiaurantieae*
1. Basidioma red-orange; stipe not changing color on bruising 2
2. Basidiospores relatively broader ($L_m > 4 \mu m$) *R. aurantibrevispora*
2. Basidiospores relatively narrower ($L_m < 4 \mu m$) *R. verrucosiflava*

Key to the species of ser. *Conjunctipesae* from China

1. Apices yellow, stipe and branches salmon to light pink 2
1. Basidioma pale yellow to dark yellow overall 3
2. Average length of basidiospores $> 8 \mu m$ *R. microsporoflava*
2. Average length of basidiospores $< 8 \mu m$ *R. sinoconjunctipes*
3. Slightly changing color to brownish yellow on bruising ... *R. flaviaggregata*
3. Almost not changing color on bruising *R. pallidoflava*

Key to the species of ser. *Flava* from China

1. Basidiospores elongated, with a high length-to-width ratio ($Q_m > 3$) *R. flavolongispora*
1. Basidiospores have a slightly smaller length-to-width ratio ($Q_m < 3$) 2
2. Basidioma deep yellow to light brown 3
2. Basidioma creamy to light yellow when young; color deepens on maturity or injury 4
3. Basidioma yellow, stipe stout stipes ... *R. pallidobrunnea*
3. Basidioma light brown, stipe relatively slender; apices bruise brown *R. barenthalensis*
4. Not changing color on bruising *R. verrucula*
4. Changing color on bruising 5
5. Basidiospores have a relatively long average length ($L_m > 13 \mu m$), dark brown on bruising *R. laevibrunnea*
5. Basidiospores have a slightly shorter average length ($L_m < 13 \mu m$) *R. hepatica*

Key to the species of ser. *Flavescentoides* from China

1. Basidioma pale yellow and easily brunnescent, stout stipes, slender branches *R. brunneipes*
1. Basidioma pale yellow to dark yellow, not changing color 2
2. Basidioma pale yellow, branches short *R. flavescentoides*
2. Basidioma dark yellow, stipe stout 3
3. Basidioma cauliflower-shaped, branches short and stout, flattened stipe *R. compressipes*
3. Branches slender and long *R. obtusa*

Key to the species of ser. *Formosae* from China

1. Average basidiospores length $< 10 \mu m$... *R. pallidicarnea*
1. Average basidiospores length $> 10 \mu m$ 2
2. Stipe long, branches sparse *R. longicarnea*
2. Basidioma cream to ochre-yellow, branches dense to sparse *R. formosoides*

Key to the species of ser. *Gelatinosae* from China

1. Clamps is frequent 2
1. Clamps are uncommon in both basidia and tramal hyphae 3
2. Basidioma yellow-orange; basidiospores relatively longer ($8.9\text{--}11.1 \times 3.5\text{--}5.1 \mu m$); distributed in southwestern China *R. gelatinostipes*
2. Basidioma saffron-yellow; basidiospores relatively shorter ($7.0\text{--}10.0 \times 4.0\text{--}5.0 \mu m$); distributed in north China *R. flavicoralloides*
3. Basidioma light to vivid yellow 4
3. Basidioma yellow-orange or apices pink to red 9
4. Average basidiospores length $< 10 \mu m$ *R. brevigelatinosa*
4. Average basidiospores length $> 10 \mu m$ 5
5. Distributed in north China (Shanxi) 6
5. Distributed in southwestern 7
6. Basidiomata saffron-yellow to light brown; basidiospores relatively shorter ($9.0\text{--}11.0 \times 3.0\text{--}5.0 \mu m$); distributed in north China (Shanxi) *R. apicaliochracea*
6. Basidiomata pale yellow to yellow; basidiospores relatively longer ($10.0\text{--}12.5 \times 3.8\text{--}5.0 \mu m$); distributed in north China (Shanxi) *R. platyrugosa*
7. Distributed in central China *R. hunanensis*
7. Distributed in southwestern China 8
8. Branches slender, basidioma bright yellow *R. subthindii*
8. Basidioma vivid yellow *R. gelatinosivivida*
9. Basidioma or apices pink to red color 10
9. Basidioma yellow to orange overall 13
10. Average basidiospores length $> 10 \mu m$ *R. rubrisubtilis*
10. Average basidiospores length $< 10 \mu m$ 11
11. Average basidiospores length $< 8 \mu m$, apices pink *R. indoyunnaniana*
11. Average basidiospores length $8 \mu m < L_m < 10 \mu m$ 12
12. Apices dark red, color does not notably fade after drying *R. rubroapicalis*
12. Apices relatively light in color, color fades at maturity *R. microspore*
13. Slender branches, average basidiospores length $> 13 \mu m$ *R. sinensis*
13. Average basidiospores length $< 13 \mu m$ 14
14. Branching dense, no change in color on bruising *R. subgelatiniaurantieae*
14. Surface of stipes and branches wrinkled and change color to brown on bruising *R. gelatinifusca*

Key to the species of ser. *Hemirubellae* from China

1. Average basidiospores length $< 10 \mu m$ *R. hemirubella*
1. Average basidiospores length $> 10 \mu m$ 2
2. Spore length (L_m) exceeding $12.5 \mu m$ *R. lingkongshanensis*
2. Spore length between $10 \mu m < L_m < 12.5 \mu m$ 3
3. Apices light pinkish cinnamon to light ochraceous cinnamon *R. eryuanensis*
3. Apices pink to purple-red colored, distributed in Yunnan Province *R. delicorosea*

Key to the species of ser. *Laetae* from China

1. Clamps rare of basidia base and tramal hyphae2
1. Clamps common3
2. Basidioma bright orange; apices turned to dark brown when hurt..... *R. aurantiapicalis*
2. Basidioma pale yellow; apices concolor with branches
..... *R. cadmioaurantiaca*
3. Basidioma yellow to yellowish orange *R. robustiflava*
3. Basidioma flesh pink to bright orange4
4. Basidioma bright orange *R. laeta*
4. Basidioma flesh pink *R. xizangensis*

Key to the species of ser. *Laeviformosoides* from China

1. Basidiospores almost smooth, basidioma light colored. .
..... *R. laeviformosoides*
1. Basidiospores almost smooth, basidioma yellow colored
..... *R. laeviflava*

Key to species of ser. *Leiosporae* from China

This series is monotypic, containing only *R. schildii*.

Key to species of ser. *Lineariflavae* from China

This series is monotypic, containing only *R. lineariflava*.

Key to species of ser. *Longisporae* from China

This series is monotypic, containing only *R. pseudolongispora*.

Key to species of ser. *Luteae* from China

This series is monotypic, containing only *R. sanguinixantha*.

Key to the species of ser. *Nanisporeae* from China

1. Basidioma red-orange, with a reddish hue; average basidiospores length $> 10 \mu\text{m}$ *R. rubrosporula*
1. Basidioma red-orange, with a reddish hue; average basidiospores length $< 10 \mu\text{m}$ 2
2. Hyphae and basidia base both have clamps *R. nanispora*
2. Hyphae almost lack clamps, without clamps at basidia base *R. corallina*

Key to the species of ser. *Neoformosae* from China

1. With clamps2
1. Clamps absent13
2. Basidioma pale yellow to light orange; average basidiospores length $L_m < 10 \mu\text{m}$ *R. luteoaurantiaca*
2. Average basidiospores length $L_m > 10 \mu\text{m}$ 3
3. Basidioma pale yellow, clamps common in basidia but rare in hyphae, average basidiospores length $L_m = 14.20 \mu\text{m}$
..... *R. distinctissima*
3. Clamps common in basidia and hyphae4
4. Distributed in north China (Shanxi) *R. cyanophila*
4. Distributed in southwestern China5
5. Average basidiospores length $L_m > 14 \mu\text{m}$ 6
5. Average basidiospores length $10 \leq L_m \leq 14 \mu\text{m}$ 7
6. Basidioma orange-red to light brown, average basidiospores length $L_m > 15 \mu\text{m}$ *R. sinolargentii*
6. Basidioma salmon to orange, average basidiospores length $> 16 \mu\text{m}$ *R. longiaurantiaca*
7. Basidioma pale yellow, lemon-yellow on bruising; average basidiospores length $12 < L_m < 14 \mu\text{m}$ ($L_m = 12.52 \mu\text{m}$)
..... *R. brunnescentiflava*
7. Average basidiospores length $10 \mu\text{m} < L_m < 12 \mu\text{m}$ 8
8. Basidioma reddish-orange9

8. Basidioma salmon to pale yellow 10
9. Apices yellow-orange, darker than the pale yellow of branches, changing color to brown on bruising, distributed in central and northeastern China *R. aureoapicalis*
9. Branches salmon, distributed in southwest and eastern China *R. hilaris*
10. Stipe single 11
10. Stipe falsely fasciculate 12
11. Stipe stout; changing color to brown on bruising
..... *R. robustibrunnea*
11. Stipe slender; not changing color on bruising
..... *R. aureolinearis*
12. Basidioma short and stout, stipe surface rapidly fading after collection *R. ephemeroforma*
12. Basidioma slender, changing color to light brown on bruising *R. aurantiformosa*
13. Average basidiospores length $L_m > 13 \mu\text{m}$, width $l_m > 13 \mu\text{m}$ 14
13. Average basidiospores length $12 \mu\text{m} \leq L_m \leq 13 \mu\text{m}$, width $4 \mu\text{m} \leq l_m \leq 6 \mu\text{m}$ 15
14. Basidioma red-orange, branches very crowded, stipe slender *R. aurantilinearis*
14. Basidioma long and high, stipes long . *R. hypogaeoides*
15. Branches elongate; distributed in central China (Shanxi)
..... *R. subcolumnaris*
15. Branches relatively dense and short 16
16. Basidioma salmon; branches dispersing, internodes gradually wide; distributed in north China (Shanxi)
..... *R. peisicinoflava*
16. Basidioma pale orange to orange 17
17. Basidioma broad and short, stipes stout and short
..... *R. linearis*
17. Basidioma salmon to yellow-orange, stipe falsely fasciculate 18
18. Branches dense, short and stout, apices rounded
..... *R. pseudoobtusissima*
18. Branches relatively slender, apices acute 19
19. Growing in coniferous forests, distributed in southwestern and northwestern and east China *R. conferta*
19. Growing in broad-leaved or mixed forests, distributed in southwestern China *R. sinosubtilis*

Key to species of ser. *Pallidochraceus* from China

This series is monotypic, containing only *R. pallidochracea*.

Key to species of ser. *Pallidolilacinae* from China

This series is monotypic, containing only *R. pallidolilacina*.

Key to species of ser. *Pseudobotrytes* from China

This series is monotypic, containing only *R. rufoaurea*.

Key to species of ser. *Pseudocystidiophorae* from China

This series is monotypic, containing only *R. pseudocystidiophora*.

Key to species of ser. *Robustipurpureae* from China

This series is monotypic, containing only *R. robustipurpurea*.

Key to the species of ser. *Roseobrunneae* from China

1. Basidioma pale yellow to pale orange; with clamps.....
..... *R. densiapiicalis*
1. Basidioma brown, with pink tint; without clamps
..... *R. roseobrunnea*

Key to the species of ser. *Sanguinipesae* from China

1. Basidia base or contextual hyphae with clamps
.....*R. rubriattenuipes*
1. Basidia base and contextual hyphae with clamps2
2. Basidioma pale yellow, changing color to dark red on bruising*R. sanguinipes*
2. Basidioma salmon, apices deep red*R. rubriapicalis*

Key to species of ser. *Semigelatinosae* from China

This series is monotypic, containing only *R. semigelatinosa*.

Key to species of ser. *Sparsiaggregatae* from China

This series is monotypic, containing only *R. sparsiaggregata*.

Key to the species of ser. *Spinulosae* from China

1. Basidiospores rounded and broad, length-to-width ratio < 2*R. purpureivariabilis*
1. Basidiospores length-to-width ratio > 22
2. Basidiospores average dimensions 10.01 × 4.89 μm, distributed in Yunnan Province.....*R. purpurea*
2. Basidiospores average dimensions 11.38 × 5.62 μm, distributed in Sichuan Province*R. sinospinulosa*

Key to the species of ser. *Zebrisporae* from China

1. Basidiospores larger than 10 μm*R. zebrispora*
1. Basidiospores smaller than 10 μm*R. linearioides*

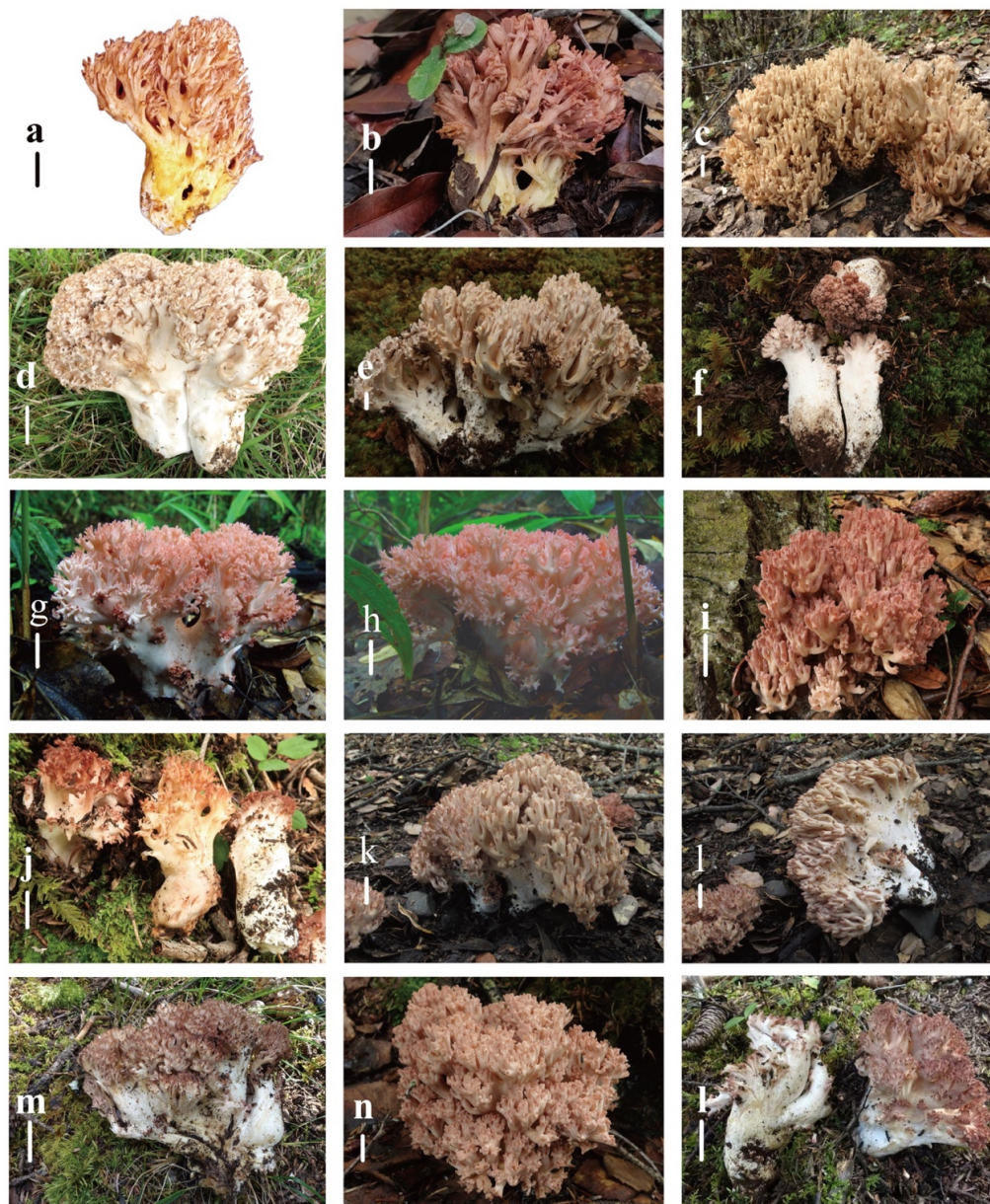


Fig. 13 Fresh basidiomata of representative species in *Ramaria* ser. *Botrytes*. **a–b** *R. flavopurpurea* (Holotype, a, MHHNU 6595; b, MHHNU 11634); **c–d** *R. luteoliparva* (Holotype, c, MHHNU 10013; d, MHHNU 10025); **e–f** *R. magnibotrys* (Holotype, e, MHHNU 11364; f, MHHNU 11365); **g–h** *R. orientolibotrytis* (Holotype, g, h, MHHNU 7165); **i–j** *R. rubropurpurea* (Holotype, i, MHHNU 10846; j, MHHNU 10767); **k–l** *R. sinobotrytis* (Holotype, k, l, MHHNU 9268); **m–n** *R. violaceoaurantia* (Holotype, m, MHHNU 10074; n, MHHNU 10002; l, MHHNU 10078); Bars =2 cm.

Ramaria* ser. *Botrytes Corner, Beih. Nova Hedwigia 33: 240 (1970)

Diagnosis: This series includes 7 species collected in China, all of which feature striped basidiospores, stout stipes, with bruising causing a color from light yellow to wine-red. Branching and apices display colors ranging from creamy to purple red.

Type species: *R. botrytis* (Pers.) Bourdot, Rev. Sci. Bourb. Centr. Fr. 7: 119-126 (1894)

Description: 1) basidiomata are milk white to pale yellow, with apices ranging from pale red, red-orange, dark purple; 2) the stipe is stout and nearly does not change color when injured; 3) basidia base and hyphae have clamps; 4) basidiospores are ornamented with conspicuous striae.

Commentary: This series includes seven species collected in China.

10. ***Ramaria flavopurpurea*** P. Zhang & Xue L. Gao, **sp. nov.** Fig. 13 a–b and Fig. 40

MycoBank: MB 852968

Etymology: The proposed compound epithet “*flavopurpurea*” refers to the basidiomata being red-purple in

color, with the stipe of the species changing to lemon yellow when handled.

Diagnosis: Differs from other species of ser. *Botrytes* by its stipe bruising to a lemon-yellow color.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 2 August 2001, P. Zhang 95 (Holotype, MHHNU 7165, GenBank Acc. No.: ITS = PP467112, nrLSU = PP493444, *tef1-α* = PP480338).

Description: *Basidiomata* 13 cm high and 11 cm broad. *Stipe* 6 × 3 cm, single, falsely fasciculate, to compound-connate, with a few abortive branchlets, off-white (1A1) to cream (4A3), with a hint of pink upward; slowly changing color to lemon yellow (4A3) when handle; flesh solid, off-white (1A1), flesh to fibrous, drying soft, easily penetrated. *Major branches* several, compound at base, ascending. *Branches* in 2–5 ranks, short and crowded; reddish lilac (14B4); axils narrowly rounded; internodes all short. *Apices* are sometimes finely divided, acute, double-dichotomous, usually gross, short and crowded, rose (12A4) to grayish magenta (13D5). Odor weakly fragrant; taste negligible.



Fig. 14 Fresh basidiomata of representative species in ***Ramaria* ser. *Brunnescentiaurantiæ***. **a–b** *R. aurantibrevispora* (a, MHHNU 11650; b, MHHNU 11642); **c–d** *R. brunnescentiaurantia* (Holotype, c, MHHNU 10772; d, MHHNU 10812); **e–f** *R. verrucosiflava* (Holotype, e, MHHNU 9908; f, MHHNU 9904). Bars = 2 cm.



Fig. 15 Fresh basidiomata of representative species in *Ramaria* ser. *Coniunctipesae*. **a–b** *R. flaviaggregata* (Holotype, a, MHHNU 10565; b, MHHNU 6952); **c–d** *R. microsporoflava* (Holotype, c, MHHNU 31326; d, MHHNU 11313); **e–f** *R. pallidoflava* (Holotype, e, MHHNU 11652; f, MHHNU 33498); **g–h** *R. sinoconjunctipes* (g, MHHNU 11645; h, MHHNU 9940). Bars = 2 cm.



Fig. 16 Fresh basidiomata of representative species in *Ramaria* ser. *Flavae*. **a–b** *R. barenthalensis* (a, MHHNU 10091; b, MHHNU 10819); **c–d** *R. flavolongispora* (Holotype, c, MHHNU 11653; d, HKAS123587); **e–f** *R. hepatica* (Holotype, e, MHHNU 10916; f, MHHNU 10915); **g–h** *R. laevibrunnea* (Holotype, g, HKAS 105942; h, MHHNU 11639); **i–j** *R. pallidobrunnea* (Holotype, i, MHHNU 9213; j, MHHNU 9985); **k–l** *R. verrucula* (Holotype, k, MHHNU 31735; l, MHHNU 31736). Bars =2 cm.

Basidiospores [60/2/2] (13.0–)14.0–18.0 × 5.0–6.0(–6.5) μm , $L_m = 15.93 \mu\text{m}$, $l_m = 5.48 \mu\text{m}$, $Q = (2.15\text{--}) 2.50\text{--}3.60$, $Q_m = 2.92 \pm 0.39$, long-ellipsoid, conspicuously striae in profile, strongly cyanophilous; *Basidia* 60–75 × 8–12 μm , clavate, clamped at base; sterigmata mostly 4, 3–8 μm , stout and straight. *Subhymenium* rudimentary, hyphal. *Hymenium* unthickening. *Tramal hyphae* of stipe 6–12 μm wide, hyaline, conspicuously clamped, thin to thick-walled (wall up to 0.5 μm thick), easily broken, interwoven, not agglutinated or adherent; ampulliform clamps up to 15 μm broad, thick-walled (wall up to 1 μm thick), with conspicuous stalactiform ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae* of upper branches up to slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated or adherent, parallel and hardly branched inward; ampulliform clamps

occasional; gloeoplerous hyphae not observed.

Ecology: In broad-leaved or coniferous forest; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan).

Additional material examined: CHINA, YUNNAN PROVINCE: Chuxiong, Lufeng City, Tuoan Township, 21 July 2022, Xue L. Gao 19718 (MHHNU 11630).

Commentary: Its basidiomata morphology is quite distinctive. Unlike most species in ser. *Botrytes*, where the reddish-purple coloration is more intense at the apices and bruising appears light brown to wine-red, features of *R. flavopurpurea* branches that are entirely purple, with the stipe bruising to lemon yellow. This characteristic allows for quick identification in the wild.

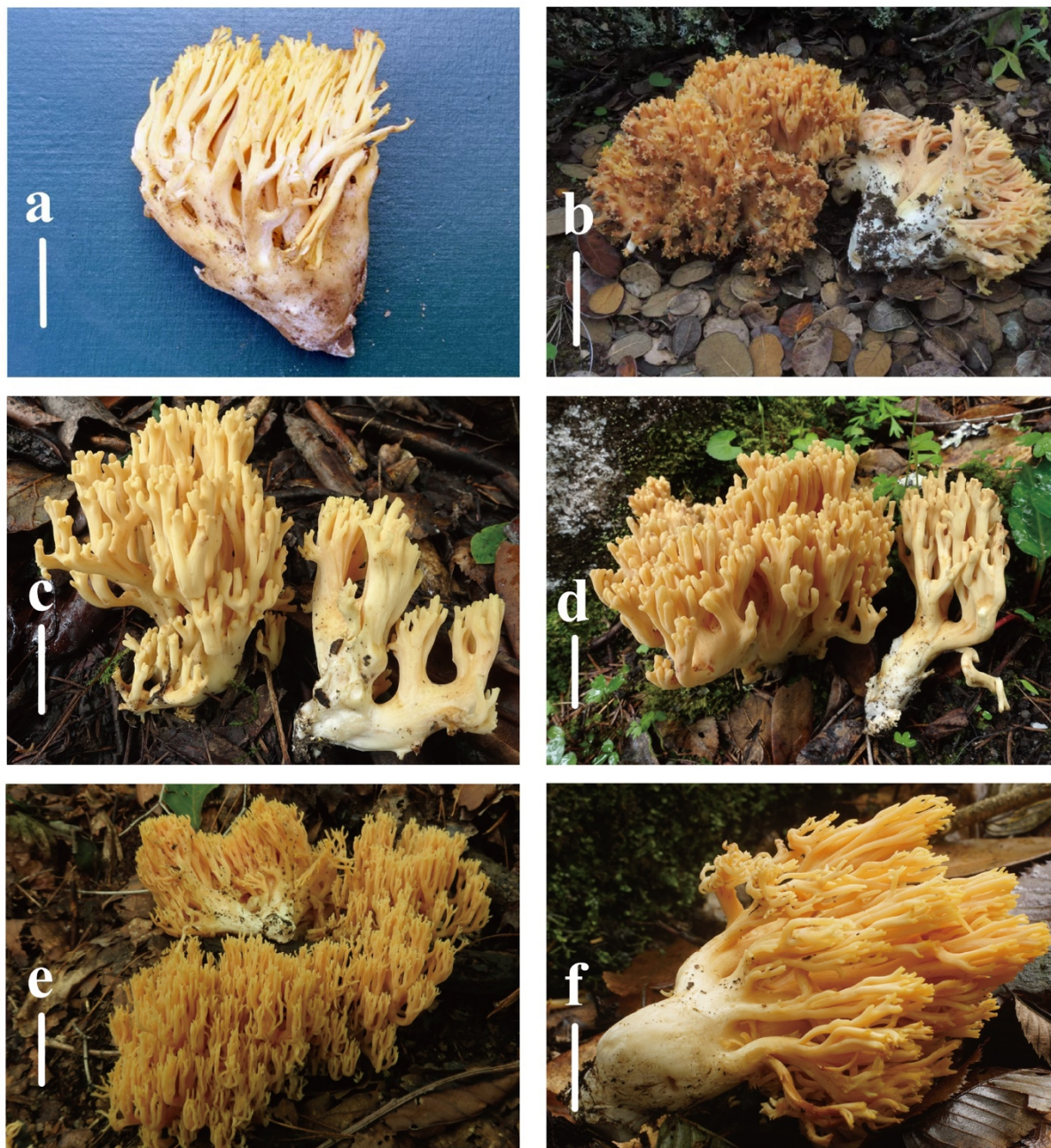


Fig. 17 Fresh basidiomata of representative species in *Ramaria* ser. *Flavescentoides*. **a** *R. brunneipes* (MHHNU 6623); **b** *R. compressipes* (Holotype, MHHNU 11644); **c–d** *R. flavescentoides* (c, MHHNU 9996; d, MHHNU 9983); **e–f** *R. obtusa* (e, MHHNU 10553; f, MHHNU 7764). Bars = 2 cm.

11. *Ramaria luteoliparva* P. Zhang & J. Zhong, **sp. nov.** Fig. 13 c–d and Fig. 41

Mycobank: MB 852972

Etymology: *luteoliparva* = *luteolus* + *parva*, proposed because this species has cream-colored basidiomata and small basidiospores.

Diagnosis: Differs from other species in the series by having the smallest basidiospores size and its basidiomata apices that lack the reddish-purple hue, appearing light brown instead.

Type: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August

2018, P. Zhang 3513 (Holotype, MHHNU 10013, GenBank Acc. No.: ITS = PP467120, nrLSU = PP493451, *tef1-α* = PP480345).

Description: *Basidiomata* 14–15 × 10–15 cm high and 8–28 cm broad, big-sized. *Stipe* stout, up to 2 × 1 cm, single, falsely fasciculate, to compound-connate, with a few abortive branchlets, off white (1A1) to cream (4A3), not changing color or slowly and slightly turned to grayish yellow (2B5) where handled; flesh off-white (1A1), flesh to fibrous, drying soft, easily penetrated. *Major branches* several, indistinct. *Branches* in 2–4 ranks, short and crowded; cream (4A3) to dull yellow (3B3); axils narrow rounded; internodes all short. *Apices* short and crowded, cream (4A3) to yellow ochre (5C7). Odor weakly fragrant; taste sweet.



Fig. 18 Fresh basidiomata of representative species in *Ramaria* ser. *Formosae*. **a–b** *R. formosoides* (a, MHHNU 10760; b, MHHNU 10554); **c–d** *R. longicarnea* (Holotype, c, MHHNU 11329; d, MHHNU 11249); **e–f** *R. pallidicarnea* (Holotype, e, MHKMU HT469; f, MHHNU 11635). Bars = 2 cm.

Basidiospores $[60/2/2]9.0\text{--}12.7\text{--}(14.0) \times (3.0\text{--})3.50\text{--}4.8\text{--}(5.0) \mu\text{m}$, $L_m = 10.75 \mu\text{m}$, $l_m = 3.92 \mu\text{m}$, $Q = (2.00\text{--})2.25\text{--}3.33\text{--}(3.53)$, $Q_m = 2.74 \pm 0.35$, subcylindrical, conspicuously striae in profile, strongly cyanophilous; *Basidia* $45\text{--}60 \times 7\text{--}12 \mu\text{m}$, clavate, clamped at base; sterigmata mostly 4, $2\text{--}5 \mu\text{m}$, stout and straight. *Hymenium* unthickening; *Subhymenium* rudimentary, hyphal. *Tramal hyphae* of stipe $6\text{--}12 \mu\text{m}$ wide, hyaline, conspicuously clamped, thin to thick-walled, interwoven, not agglutinated or adherent; ampulliform clamps up to $15 \mu\text{m}$ broad, usually not thick-walled; gloeoplerous hyphae not observed. *Tramal hyphae* of upper branches slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated or adherent, parallel and tightly interwoven;

ampulliform clamps occasional, unornamented; gloeoplerous hyphae not observed.

Ecology: In broad-leaved or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Xizang, Yunnan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4329 (MHHNU 10829). XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3525

(MHHNU 10025).

Commentary: The species has the smallest basidiospores within the series. Other main features of *R. luteoliparva* include: 1) large-sized basidiomata; 2) basidiomata are cream-colored with yellow ochre color apices; 3) color

changes to pale brown to dark brown when injured; 4) basidiospores are ornamented with longitudinal striae and are less 11 μm in size; 5) hyphae and basidia base have clamps.



Fig. 19 Fresh basidiomata of representative species in *Ramaria* ser. *Gelatinosae*. **a–b** *R. brevigelatinosa* (Holotype, a, MHHNU 11283; b, MHHNU 11269); **c–d** *R. hunanensis* (Holotype, c, MHHNU 7140; d, MHHNU 9727); **e–f** *R. gelatinifusca* (Holotype, e, MHHNU 9936; f, MHHNU 11347); **g–h** *R. gelatinosivivida* (Holotype, g, MHHNU 10089; h, MHHNU 10083); **i–j** *R. gelatinostipes* (i, MHHNU 10826; j, MHHNU 10762); **k–l** *R. indoyunnaniana* (k, MHHNU 9134; l, MHHNU 9839); **m–n** *R. microspora* (m, MHHNU 9914; n, MHHNU 6619); **o–p** *R. rubrisubtilis* (Holotype, o, MHHNU 7160; p, MHHNU 11651); **q–r** *R. rubroapicalis* (Holotype, q, MHHNU 11218; r, MHHNU HT277); **s–t** *R. sinensis* (s, MHHNU 9177; t, MHHNU 9878); **u–v** *R. subgelatiniaurantia* (Holotype, u, MHHNU 10859; v, MHHNU 10858); **w–x** *R. subthindii* (Holotype, w, MHHNU 9131; x, HKAS55387). Bars = 2 cm.

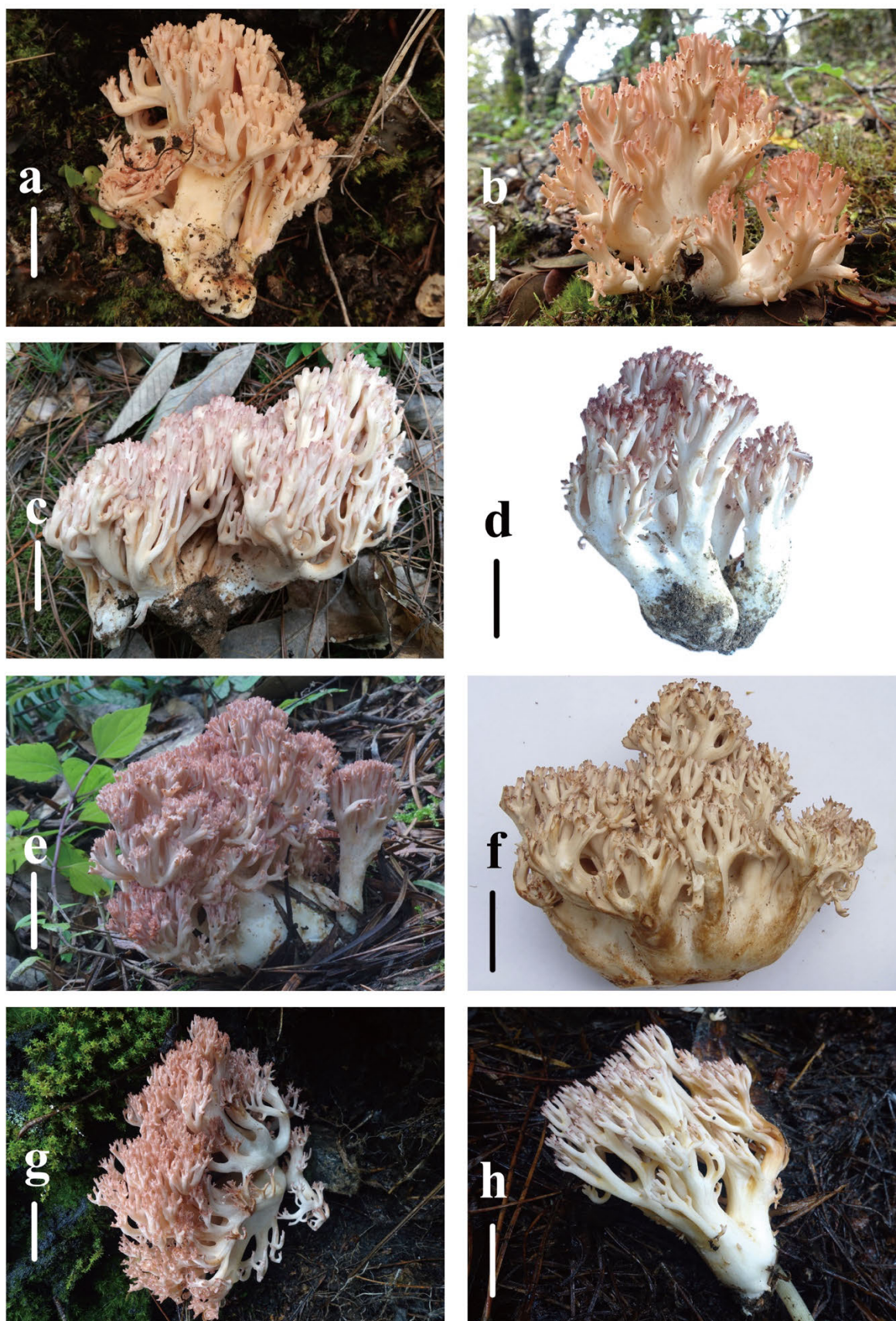


Fig. 20 Fresh basidiomata of representative species in *Ramaria* ser. *Hemirubellae*. **a–b** *R. eryuanensis* (a, MHHNU 10837; b, MHHNU 9915); **c–d** *R. delicorosea* (Holotype, c, MHHNU 31322; d, MHHNU 8882); **e–f** *R. hemirubella* (e, MHHNU 31267 and f, MHHNU 7202); **g–h** *R. lingkongshanensis* (g, MHHNU 9873; h, MHHNU 9874). Bars =2 cm.

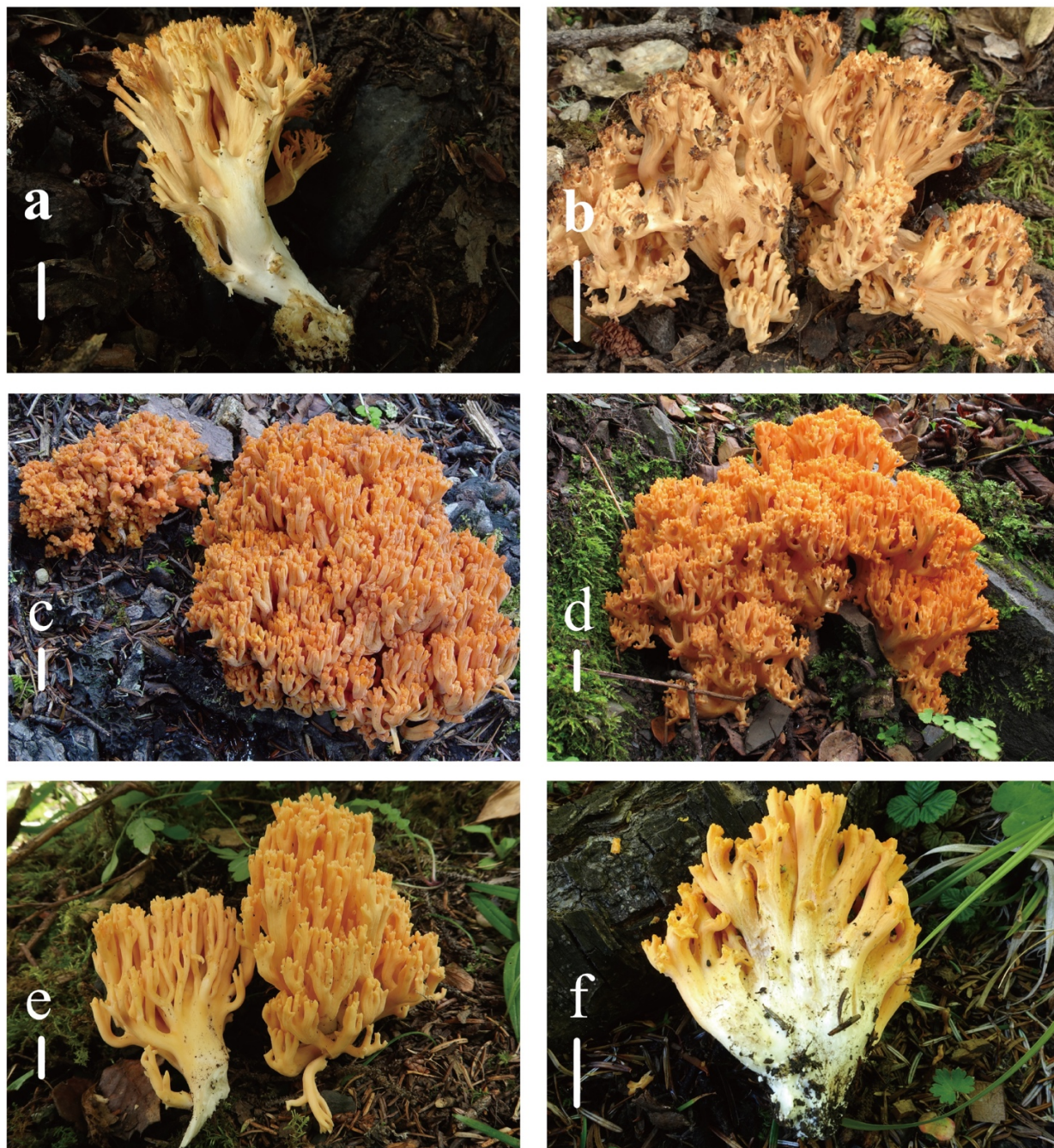


Fig. 21 Fresh basidiomata of representative species in *Ramaria* ser. *Laetae*. **a–b** *R. aurantiapicalis* (Holotype, a, MHHNU 10099; b, MHHNU 10100); **c–d** *R. laeta* (Holotype, c, HKAS49037; d, MHHNU 33922); **e–f** *R. robustiflava* (Holotype, e, MHHNU 10090; f, MHHNU 9931). Bars =2 cm.

12. *Ramaria magnibotrys* P. Zhang & J. Zhong, **sp. nov.** Fig. 13 e–f and Fig. 42

Mycobank: MB 852959

Etymology: *magnibotrys*, from *magni* = large, and “-botrys” means clusters, is proposed because the basidiomata of this species are large and form clusters.

Diagnosis: Large basidiomata with apices that are wine-colored when young and cream-colored at maturity. Basidiomata do not significantly change color when injured. Basidiospores are ornamented with longitudinal striae. Hyphae and basidia base have clamps.

Type: CHINA. YUNNAN PROVINCE: Shangri-La City, Pudacuo National Park, Tianbaotai, in the mixed forest with

Quercus and *Picea*. altitude 3680 m, 1 September 2022, P. Zhang 4864 (Holotype, MHHNU 11364, GenBank Acc. No.: ITS = PP467116, nrLSU = PP493447, *tef1-α* = PP480341).

Description: *Basidiomata* 6–25 cm high and 8–28 cm broad, big-sized. *Stipe* stout, up to 3–18 × 4–16 cm, single, falsely fasciculate, to compound-connate, with a few abortive branchlets, milk white (1A2) to cream (4A3), not changing color or slowly and slightly turned to grayish yellow (2B5) where handled; flesh off-white (1A1), flesh to fibrous, drying soft, easily penetrated. *Major branches* several, indistinct. *Branches* in 2–4 ranks, short and crowded; cream (4A3) to light red (10A5) upward, concolor with stipe below; axils narrow rounded; internodes all short. *Apices* short and

crowded, cream (4A3) to grayish magenta (13D5). Odor weakly fragrant; taste sweet.

Basidiospores [60/2/2]12.0–15.1(–16.5) × (4.5–)5.0–7.0 µm, $L_m = 13.31$ µm, $l_m = 5.66$ µm, $Q = (1.71\text{--})1.93\text{--}2.67\text{--}(3.01)$, $Q_m = 2.30 \pm 0.23$, subcylindrical, conspicuously striae in profile, strongly cyanophilous; **Basidia** 60–75 × 8–12 µm, clavate, clamped at base; sterigmata mostly 4, 3–7 µm, stout and straight. **Hymenium** unthickening; **Subhymenium** rudimentary, hyphal. **Tramal hyphae of stipe** 6–12 µm wide, hyaline, conspicuously clamped, thin to thick-walled, interwoven, not agglutinated or adherent; ampulliform clamps up to 15 µm broad, usually not thick-walled; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated

or adherent, parallel and tightly interwoven; ampulliform clamps occasional, unornamented; gloeoplerous hyphae not observed.

Ecology: Found in broad-leaved or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-a City, Pudacuo National Park, Tianbaotai, in the mixed forest with *Quercus* and *Picea*. altitude 3680 m, 1 September 2022, P. Zhang 4865 (MHHNU 11365); same location, in the mixed forest with *Quercus* and *Picea*. altitude 3523 m, 3 August 2022, Jian W. Liu MF94 (MHHNU 11646).



Fig. 22 Fresh basidiomata of representative species in *Ramaria* ser. *Laeviformosoides*. **a–b** *R. laeviflava* (Holotype, **a**, MHHNU 9909; **b**, MHHNU 9907); **c–d** *R. laeviformosoides* (**c**, MHHNU 8599 and **d**, HKAS 55281). Bars =2 cm.



Fig. 23 Fresh basidiomata of representative species in *Ramaria* ser. *Leiosporae*. **a–b** *R. schildii* (**a**, MHHNU 9285; **b**, MHHNU 9242). Bars =2 cm.

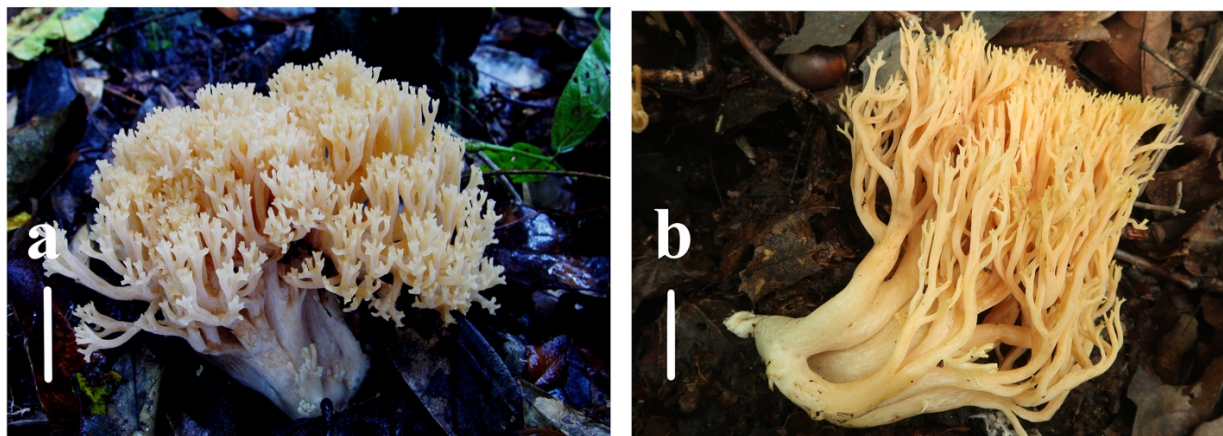


Fig. 24 Fresh basidiomata of representative species in *Ramaria* ser. *Lineariflavae*. **a–b** *R. lineariflava* (Holotype, a, MHHNU 7162; b, MHHNU 10543). Bars =2 cm.



Fig. 25 Fresh basidiomata of representative species in *Ramaria* ser. *Longisporae*. **a–b** *R. pseudolongispora* (Holotype, a, MHHNU 10059; b, MHHNU 9888). Bars =2 cm.



Fig. 26 Fresh basidiomata of representative species in *Ramaria* ser. *Luteae*. **a–b** *R. sanguinixantha* (Holotype, a, MHHNU 10842; b, MHHNU 10863). Bars =2 cm.

Commentary: *Ramaria magnibotrys* resembles *R. rubrievanescens* and *R. rubropurpurea*, as all three species exhibit stout stipes and relatively large basidiomata with creamy to purplish-red apices. However, *R. rubropurpurea* changes color to dark red, with apices that display a deep

purplish-red hue that is slow to fade. *Ramaria rubrievanescens*, on the other hand, has smaller basidiospores ($L_m = 11.8 \mu m$, Marr & Stuntz 1973).

13. *Ramaria orientolibotrytis* P. Zhang & G.W. Li, sp. nov. Fig.

13 g–h and Fig. 43

Mycobank: MB 852961

Etymology: The proposed compound epithet “*orientalibotrytis*” refers to an eastern species that is similar to *R. botrytis*.

Diagnosis: Basidiomata are medium sized to large, with a white stipe and pallid wine-colored apices. Branches are light wine-colored and turn wine-colored when injured. Basidiospores are ornamented with longitudinal striae.

Type: CHINA, HUNAN PROVINCE: Chenzhou City, Yizhang County, Mangshan National Nature Reserve, Datang Keng, in a mixed forest of broad-leaved forest and bamboo, altitude 1000 m, 6 September 2007, P. Zhang 665 (Holotype, MHHNU 7165, GenBank Acc. No.: ITS = PP467123, nrLSU = PP493454).

Description: *Basidiomata* 6–12 cm high and 5–10 cm broad, cauliflower-shaped in outline. *Stipe* 4–6 × 3–5 cm, single, falsely fasciculate, to compound-connate, with a few abortive branchlets, off-white (1A1) with a hint of shell pink (8A3) upward, flesh (6B3) in age, slowly easily wine red (11D8) where handled or chaffed; flesh solid, off-white (1A1), in age suffused flesh color, moist but not gelatinous or slippery, drying soft, light in weight, easily penetrated. *Major branches* 4, terete, ascending. *Branches* in 5–6 ranks, tapering upward, with shell pink (8A3) longitudinally rugulose, turned to wine red (11D8) when hurt, axils “U” shaped, straight, or slightly curved, crowded, rugulose surface, internodes diminishing gradually at maturity. *Apices* short and rounded, dark red (11C8) color. Odor weakly fragrant; taste negligible.

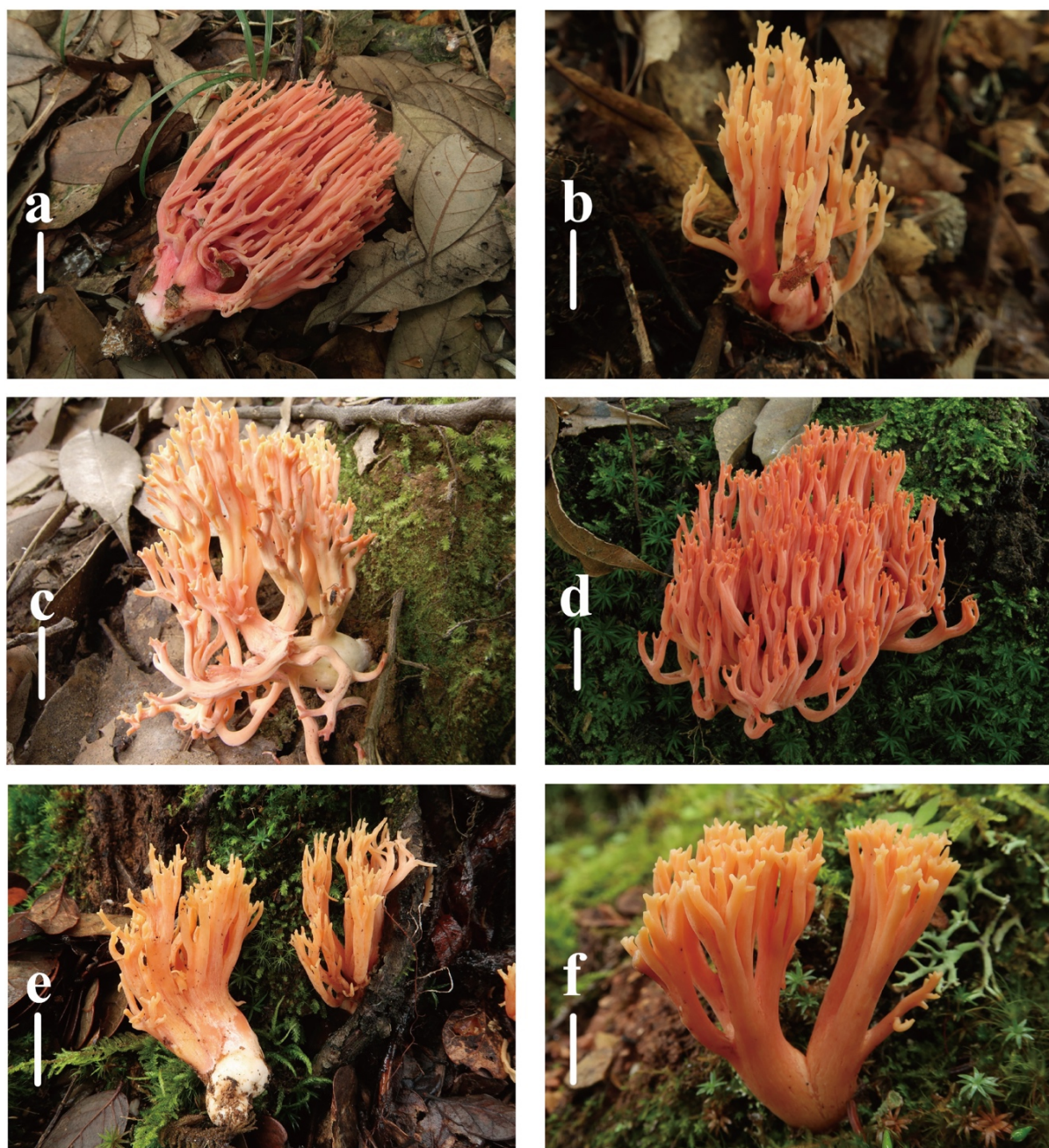


Fig. 27 Fresh basidiomata of representative species in *Ramaria* ser. *Nanisporae*. **a–b** *R. corallina* (Holotype, a, MHHNU 11212; b, MHHNU 10541); **c–d** *R. nanispora* (c, HKAS 50198; d, MHHNU 11636); **e–f** *R. rubrosporula* (Holotype, e, MHHNU 9921; f, MHHNU 9918). Bars = 2 cm.



Fig. 28 Fresh basidiomata of representative species in *Ramaria* ser. *Neoformosae*. **a–b** *R. aurantiformosa* (Holotype, a, MHHNU 9180; b, MHHNU 11361); **c–d** *R. aurantilinearis* (Holotype, c, MHHNU 10756; d, MHHNU 10816); **e** *R. aureoapicalis* (Holotype, e, MHHNU 9328); **f** *R. aureolinearis* (Holotype, f, MHHNU 10533); **g** *R. brunnescentiflava* (Holotype, g, MHHNU 9290); **h** *R. distinctissima* (h, MHHNU 9980); **i** *R. ephemeroforma* (i, MHHNU 6601); **j** *R. hilaris* (j, MHHNU Yang409); **k** *R. hypogaeoides* (Holotype, k, MHHNU 9211); **l** *R. linearis* (l, MHHNU 10003); **m** *R. longiaurantia* (Holotype, m, MHHNU 10806); **n** *R. luteoaurantiaca* (n, MHHNU 10235); **o–p** *R. pseudoobtusissima* (Holotype, o, MHHNU 10064; p, MHHNU 10071); **q–r** *R. robustibrunnea* (Holotype, q, MHHNU 9269; r, MHHNU 9271); **s–t** *R. sinolargentii* (Holotype, s, MHHNU 34000; t, MHHNU 34029); **u–v** *R. sinosubtilis* (Holotype, u, MHHNU 10060; v, MHHNU 9993); **w–x** *R. conferta* (Holotype, w, MHHNU 10088; x, MHHNU 9209). Bars = 2 cm.

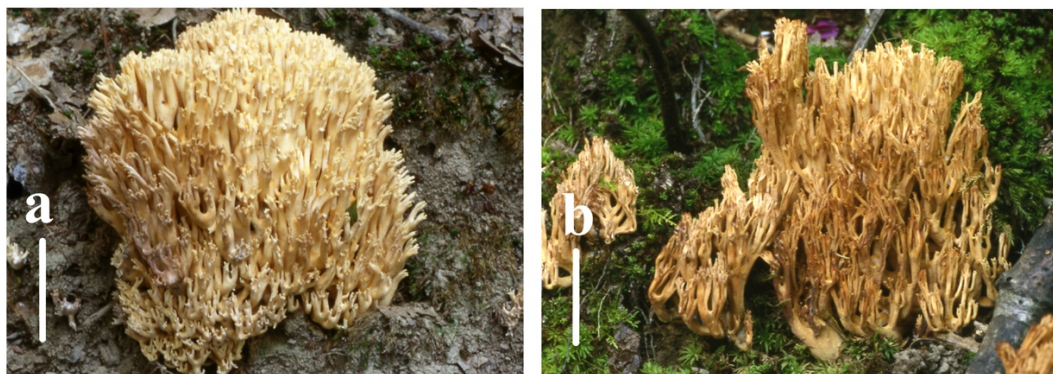


Fig. 29 Fresh basidiomata of representative species in *Ramaria* ser. *Pallidochraceus*. **a–b** *R. pallidochracea* (Holotype, a, MHHNU 6753; b, MHHNU 6752). Bars = 2 cm.

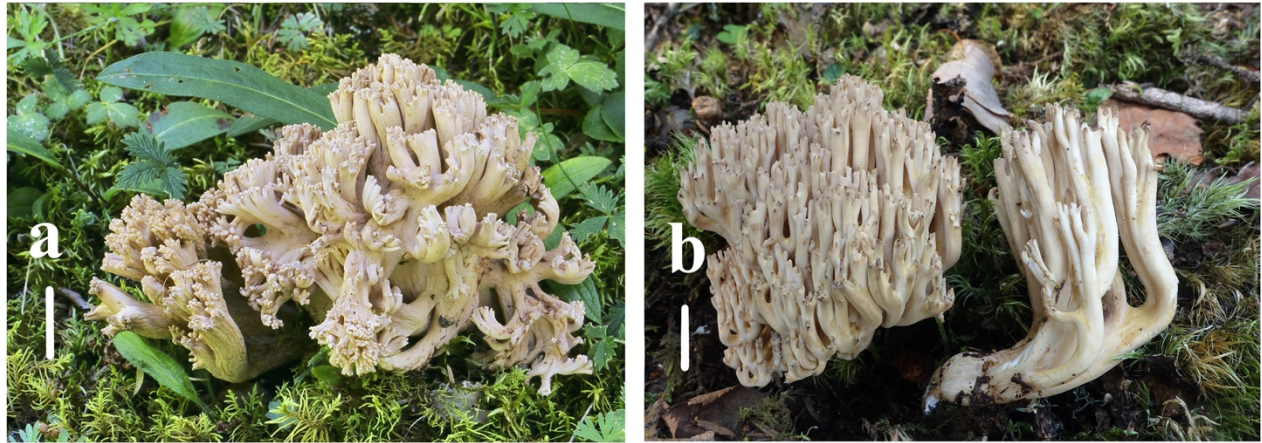


Fig. 30 Fresh basidiomata of representative species in *Ramaria* ser. *Pallidolilacinae*. **a–b** *R. pallidolilacina* (Holotype, a, HKAS46112; b, MHHNU 10080) (Zhang et al. 2005). Bars = 2 cm.



Fig. 31 Fresh basidiomata of representative species in *Ramaria* ser. *Pseudobotrytes*. **a–b** *R. rufoaurea* (Holotype, a, MHHNU 10026; b, MHHNU 10007). Bars = 2 cm.



Fig. 32 Fresh basidiomata of representative species in *Ramaria* ser. *Pseudocystidiophorae*. **a–b** *R. pseudocystidiophora* (Holotype, a, MHHNU 10023; b, MHHNU 10825). Bars = 2 cm.

Basidiospores $[60/2/2](9.0-9.1-11.9(-12.9) \times 4.0-6.2(-6.4) \mu\text{m}$, $L_m = 10.48 \mu\text{m}$, $l_m = 4.90 \mu\text{m}$, $Q = (-1.64)1.71-2.50(-2.75)$, $Q_m = 2.06 \pm 0.24$, ellipsoid to subcylindrical, conspicuously striae in profile, strongly cyanophilous; Basidia $44-60 \times 9-12 \mu\text{m}$, clavate, thin-walled, hyaline, clamped at base; weakly cyanophilous; sterigmata 4, $6-8 \mu\text{m}$, stout and straight. Subhymenium rudimentary. Hymenium thickening. Tramal

hyphae of stipe $6-12 \mu\text{m}$ wide, hyaline, conspicuously clamped, thin to thick-walled (wall up to $0.5 \mu\text{m}$ thick), easily broken, interwoven, not agglutinated or adherent; ampulliform clamps up to $15 \mu\text{m}$ broad, thick-walled (wall up to $1 \mu\text{m}$ thick), with conspicuous ornamentation; gloeoplerous hyphae not observed. Tramal hyphae of upper branches up to $2-11 \mu\text{m}$ wide, hyaline, thick-walled, conspicuously

clamped, not agglutinated or adherent, parallel and hardly branched inward, with cells cigar to barrel-shaped, outward more interwoven, gnarled, freely branched; ampulliform clamps common, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed.

Ecology: Found in broad-leaved or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from central China (Hunan).

Additional material examined: CHINA, HUNAN PROVINCE: Chenzhou City, Yizhang County, Mangshan National Nature Reserve, Zeziping, in broad-leaved forest with Fagaceae, altitude 1290 m, P. Zhang 350 (MHHNU 6850).

Commentary: *Ramaria orientolibotrytis* is the only species found in Hunan Province, central China, characterized by basidiospores ornamented with striae. Typically, species within *Ramaria* are commonly found in temperate regions with mild climates and are rarely reported in subtropical areas. However, *R. orientolibotrytis* thrives in broad-leaved forests within distinct subtropical areas. It resembles *R. botrytis* but differs in having smaller basidiospores that turn wine-color when injured ($14.2 \times 5.2 \mu\text{m}$, Franchi & Marchetti 2021). Compared to the basidiospores size of *R. rubropurpurea* ($L_m = 14.15 \mu\text{m}$, as measured in this study), *R. orientolibotrytis* has smaller basidiospores.



Fig. 33 Fresh basidiomata of representative species in *Ramaria* ser. *Robustipurpureae*. **a–b** *R. robustipurpurea* (Holotype, a, MHHNU 8877; b, MHKMU Muman575). Bars = 2 cm.



Fig. 34 Fresh basidiomata of representative species in *Ramaria* ser. *Roseobrunneae*. **a–b** *R. densipicalis* (Holotype, a, MHHNU 10012; b, MHHNU 10549); **c–d** *R. roseobrunnea* (Holotype, c, d, MHHNU 31571). Bars = 2 cm.



Fig. 35 Fresh basidiomata of representative species in *Ramaria* ser. *Sanguinipesae*. **a–b** *R. rubriapicalis* (Holotype, a, MHHNU 11382; b, MHHNU 11268); **c–d** *R. rubriattenuipes* (c, MHHNU 6578; d, HKAS 54802); **e–f** *R. sanguinipes* (e, MHHNU 11250; f, MHHNU 11253). Bars = 2 cm.



Fig. 36 Fresh basidiomata of representative species in *Ramaria* ser. *Semigelatinosae*. **a–b** *R. semigelatinosa* (Holotype, a, MHHNU 11310, b, MHHNU 10311). Bars = 2 cm.



Fig. 37 Fresh basidiomata of representative species in *Ramaria* ser. *Sparsiaggregatae*. **a–b** *R. sparsiaggregata* (Holotype, a, MHHNU 10016; b, MHHNU 10017). Bars = 2 cm.



Fig. 38 Fresh basidiomata of representative species in *Ramaria* ser. *Spinulosae*. **a–b** *R. purpurea* (Holotype, a, MHHNU 11267; b, MHHNU 9879); **c–d** *R. purpureivariabilis* (Holotype, c, d, MHHNU 31737); **e–f** *R. sinospinulosa* (Holotype, e, MHHNU 10788; f, MHHNU 10808). Bars = 2 cm.

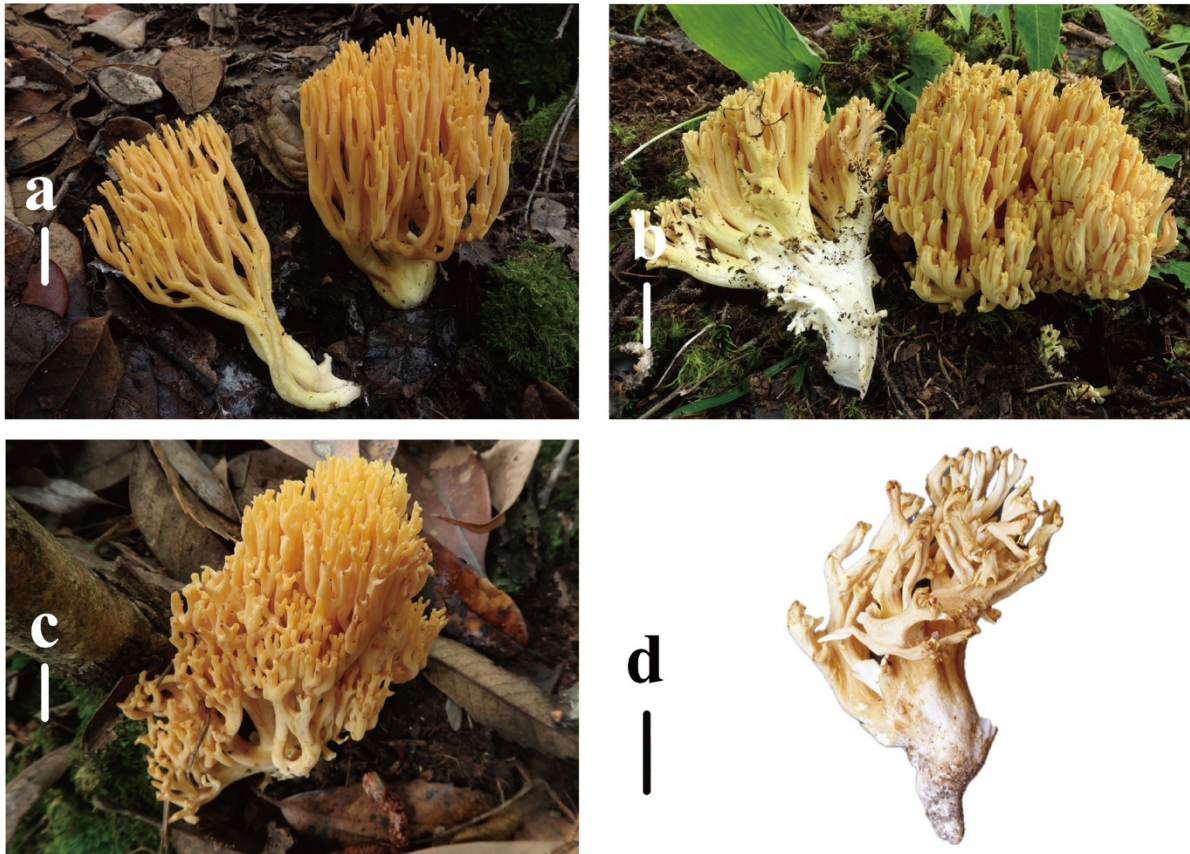


Fig. 39 Fresh basidiomata of representative species in *Ramaria* ser. *Zebrisporeae*. **a–b** *R. linearoides* (a, MHHNU 10046; b, MHHNU 10082); **c–d** *R. zebrisporea* (c, MHHNU 11272; d, MHHNU 6621). Bars = 2 cm.

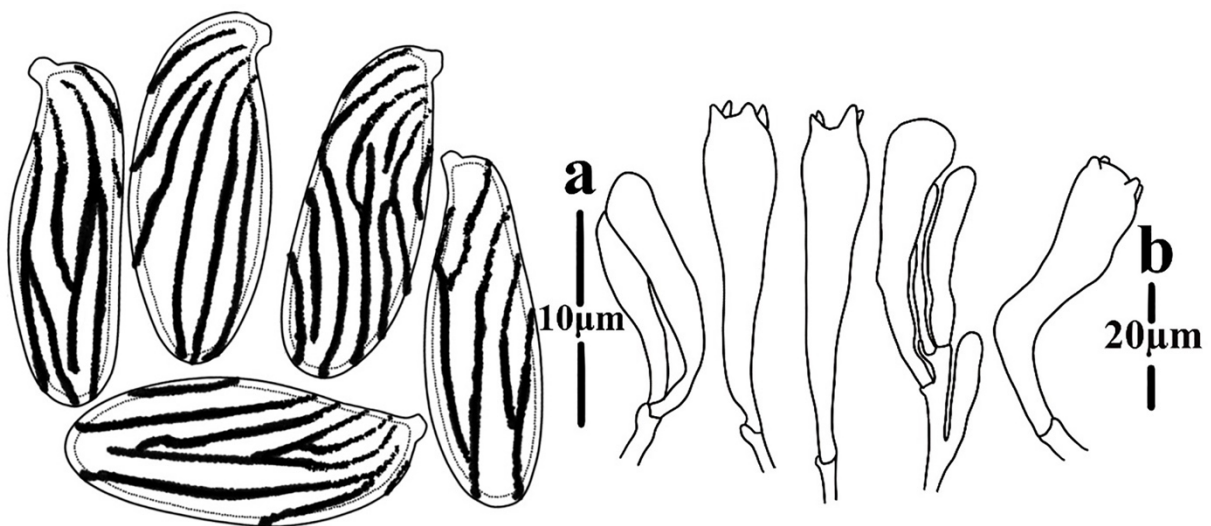


Fig. 40 Microscopic features of *R. flavopurpurea* (MHHNU 6595). **a** basidiospores; **b** basidia. Scale bars: **a** = 10 µm, **b** = 20 µm

14. *Ramaria rubropurpurea* P. Zhang & J. Zhong, **sp. nov.** Fig. 13 i–j and Fig. 44

Mycobank: MB 852944

Etymology: *rubropurpurea*, from *rubro* = red color, and *purpurea* = purple color, proposed because this species has wine-colored basidiomata that turn red when injured.

Diagnosis: The apices are wine to grayish red in color and turn wine-red when bruised. The basidiospores are

ornamented with longitudinal striae; hyphae and basidia base with clamps.

Type: CHINA. SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4346 (Holotype, MHHNU 10846, GenBank Acc. No.: ITS = PP467118, nrLSU = PP493449, *tef1-a* = PP480343).

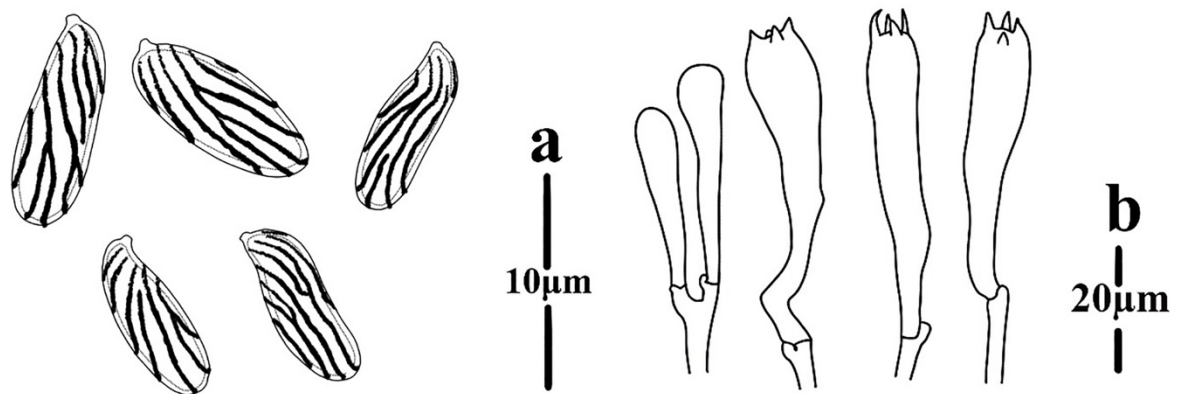


Fig. 41 Microscopic features of *R. luteoliparva* (MHHNU 10013). a basidiospores; b basidia. Scale bars: a = 10 μ m, b = 20 μ m

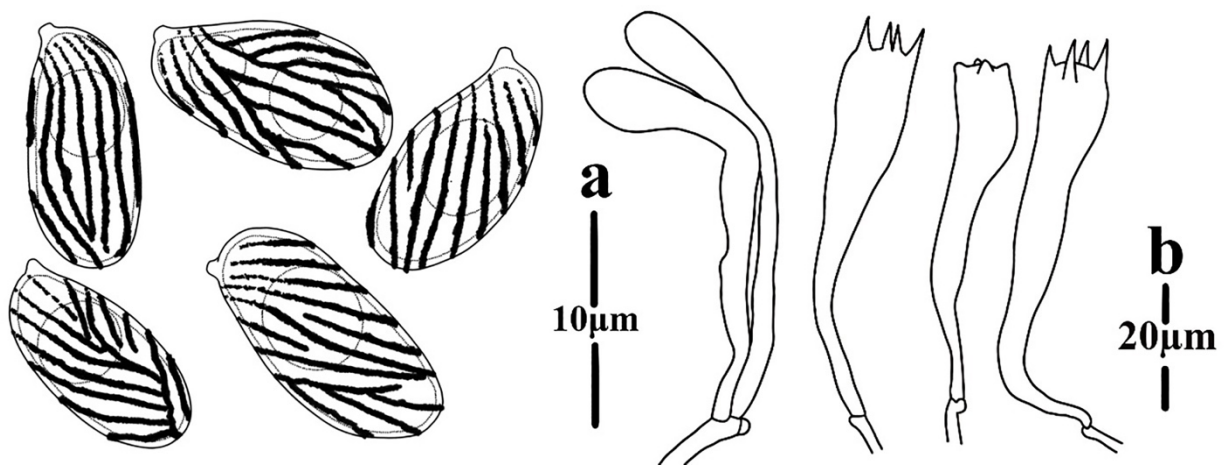


Fig. 42 Microscopic features of *R. magnibotrys* (MHHN 11364). a basidiospores; b basidia. Scale bars: a = 10 μ m, b = 20 μ m

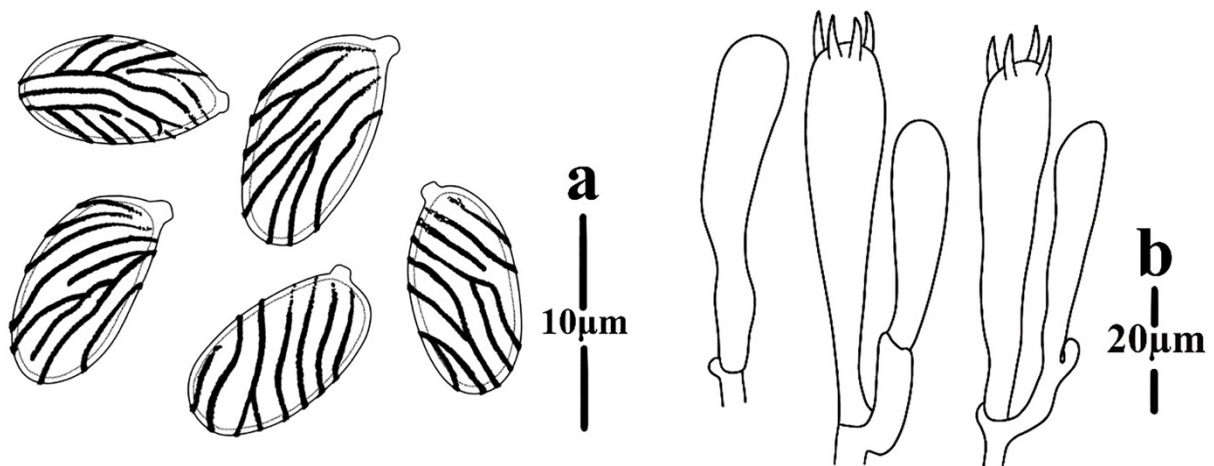


Fig. 43 Microscopic features of *R. orientolibotrytis* (MHHNU 7165). a basidiospores; b basidia. Scale bars: a = 10 μ m, b = 20 μ m.

Description: *Basidiomata* 14 cm high and 8 cm broad, big-sized. *Stipe* stout, up to 2.5 $\times$ 7 cm, single, falsely fasciculate, to compound-connate, smooth, with a few abortive branchlets, off-white (1A1) to cream (4A3), slowly turned to dark red (11C8) to wine red (11D8) where handled; flesh off-white (1A1), flesh to fibrous, drying soft, easily penetrated. *Major branches* several, indistinct. *Branches* in 2–4 ranks, short and crowded; dark red (11C8) to wine red (11D8)

upward, concolor with stipe below; axils narrow rounded; internodes all short. *Apices* short and crowded, to grayish magenta to wine red (11D8). Odor weakly fragrant; taste sweet.

Basidiospores [60/2/2](12.0–)13.0–16.0(–17.0) $\times$ 5.0–8.0 μ m, L_m = 14.15 μ m, l_m = 6.25 μ m, Q = (1.75–)1.86–2.80(–3.00), Q_m = 2.25 $\pm$ 0.25, subcylindrical, conspicuously striae in profile, strongly cyanophilous; *Basidia* 60–80 $\times$ 8–13 μ m,

clavate, clamped at base; sterigmata 1–4, mostly 4, 3–7 μm , stout and straight. *Hymenium* unthickening; *Subhymenium* rudimentary, hyphal. *Tramal hyphae* of stipe 6–12 μm wide, hyaline, conspicuously clamped, thin to thick-walled, interwoven, not agglutinated or adherent; ampulliform clamps up to 15 μm broad, usually not thick-walled; gloeoplerous

hyphae not observed. *Tramal hyphae* of upper branches slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated or adherent, parallel and tightly interwoven; ampulliform clamps occasional, unornamented; gloeoplerous hyphae not observed.

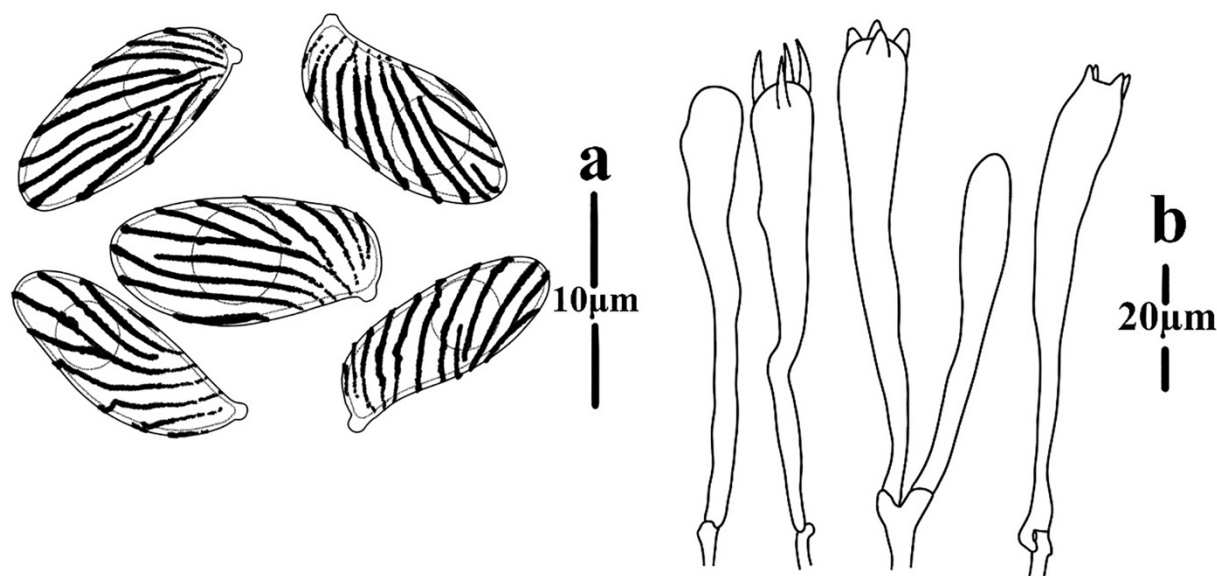


Fig. 44 Microscopic features of *R. rubropurpurea* (MHHNU 10864). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm

Ecology: Found in broad-leaved or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Sichuan, Yunnan, Xizang).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in broad-leaved forest with Fagaceae, altitude 3500 m, 1 August 2012, P. Zhang 1211 (MHHNU 7711); same city, Mugecuo, in forest dominated by *Abies* and Pinaceae, altitude 3800 m, 21 August 2017, P. Zhang 2715 (MHHNU 9215); same city, Sewulong Village, within a *Picea* forest, altitude 3450 m, 5 September 2018, P. Zhang 3597 (MHHNU 10097), P. Zhang 3598 (MHHNU 10097), P. Zhang 3601 (MHHNU 10101), P. Zhang 3603 (MHHNU 10103), P. Zhang 3604 (MHHNU 10104); same location, Gongga Mountain, in the high-altitude *Quercu* and *Picea* forests, altitude 3900 m, 5 September 2021, P. Zhang 4267 (MHHNU 10767), P. Zhang 4270 (MHHNU 10770), P. Zhang 4271 (MHHNU 10771), P. Zhang 4273 (MHHNU 10773), P. Zhang 4274 (MHHNU 10774), P. Zhang 4275 (MHHNU 10775); same location, 6 September 2021, P. Zhang 4290 (MHHNU 10790), P. Zhang 4301 (MHHNU 10301), P. Zhang 4302 (MHHNU 10302), P. Zhang 4313 (MHHNU 10313), P. Zhang 4318 (MHHNU 10318); same location, 8 September 2021, P. Zhang 4245 (MHHNU 10745), P. Zhang 4250 (MHHNU 10750), P. Zhang 4278 (MHHNU 10778); same location, 9 September 2021, P. Zhang 4269 (MHHNU 10769). YUNNAN PROVINCE: Shangri-La City, Haba Snow Mountain, Mianshaba, altitude 3100 m, 13 August 2008, Li-P. Tang 620 (HKAS 54851); same city, in the mixed forest with *Quercus* and *Picea*, altitude 3429 m, 10 August 2020, Jian W. Liu MF368 (MHHNU 11648); Lijiang, Yulong County, Yulong Snow Mountain, altitude 3700 m, 26 July 2017, P. Zhang 2797

(MHHNU 9297).

Commentary: *Ramaria magnibotrys* P. Zhang & J. Zhong and *R. rubrievanescens* Marr & D.E. Stuntz closely resemble *R. rubropurpurea*. These species are characterized by their large basidiomata, stout stipes, reddish-purple apices, and striped basidiospores. Compared to *R. rubropurpurea*, *R. magnibotrys* exhibits relatively lighter-colored apices and pale stain color on bruising, with slightly smaller basidiospores. In contrast, *R. rubropurpurea* has deeper red apices that retain their hue even when dry compared to *R. rubrievanescens*. Specimens collected from some locations exhibit pale to pinkish apices similar to *R. rubrievanescens*. This discrepancy may arise from environmental factors such as moisture or low light conditions causing the fading of the reddish-purple pigments. Nonetheless, basidiospores of *R. rubrievanescens* are smaller ($L_m = 11.8 \mu\text{m}$).

15. *Ramaria sinobotrytis* P. Zhang & J. Zhong, **sp. nov.** Fig. 13 k–l and Fig. 45

Mycobank: MB 852971

Etymology: The proposed compound epithet “*sinobotrytis*” refers to the species collected in China and being similar to *R. botrytis*.

Diagnosis: The apices and young branches exhibit a pale red-purple color, while the stipe surface gradually turns slightly lemon yellow upon handled. Basidiospores are ornamented with longitudinal striae and measure over 18 μm , with hyphae and basidia base showing clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Township, Sewurong Village, altitude 3700 m, 26 August 2017, P. Zhang 2768 (Holotype, MHHNU 9268, GenBank Acc. No.: ITS = PP467122, nrLSU = PP493453, *tef1*-

α = PP480347).

Description: *Basidiomata* 12 cm high and 15 cm broad. *Stipe* 3 × 5 cm, single, falsely fasciculate, tapering gradually downward, to compound-connate, with a few abortive branchlets, off-white (1A1) to cream (4A3), with a hint of pink upward; nearly not changing color or slowly and slightly changing color to lemon yellow (4A3) when handle; flesh solid, off-white (1A1), flesh to fibrous, drying soft, easily penetrated. *Major branches* several, compound at base. *Branches* in 2–5 ranks, short and crowded; flesh (6B3) to brownish orange (6C3), with a hint of red-purple hue; axils narrowly rounded; internodes all short. *Apices* rounded, short, crowded, rose (12A4) to grayish orange (6B5). Odor weakly fragrant; taste negligible.

Basidiospores [60/2/2]16.0–21.0(–22.0) × 6.0–9.0 μm , L_m = 18.2 μm , l_m = 7.3 μm , Q = (2.11–)2.13–3.00(–3.14), Q_m = 2.51 ± 0.27, long-ellipsoid, conspicuously striae in profile, strongly cyanophilous; *Basidia* 50–85 × 9–18 μm , clavate, clamped at base; sterigmata mostly 4, 4–9 μm , stout and straight. *Subhymenium* rudimentary, hyphal. *Hymenium* unthickening. *Tramal hyphae* of *stipe* 6–14 μm wide, hyaline, conspicuously clamped, thin to thick-walled, interwoven, not agglutinated or adherent; ampulliform clamps up to 18 μm broad, usually not thick-walled; gloeoplerous hyphae not observed. *Tramal hyphae* of *upper branches* up to slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated or adherent, parallel and hardly branched inward; ampulliform clamps occasional; gloeoplerous hyphae not observed.

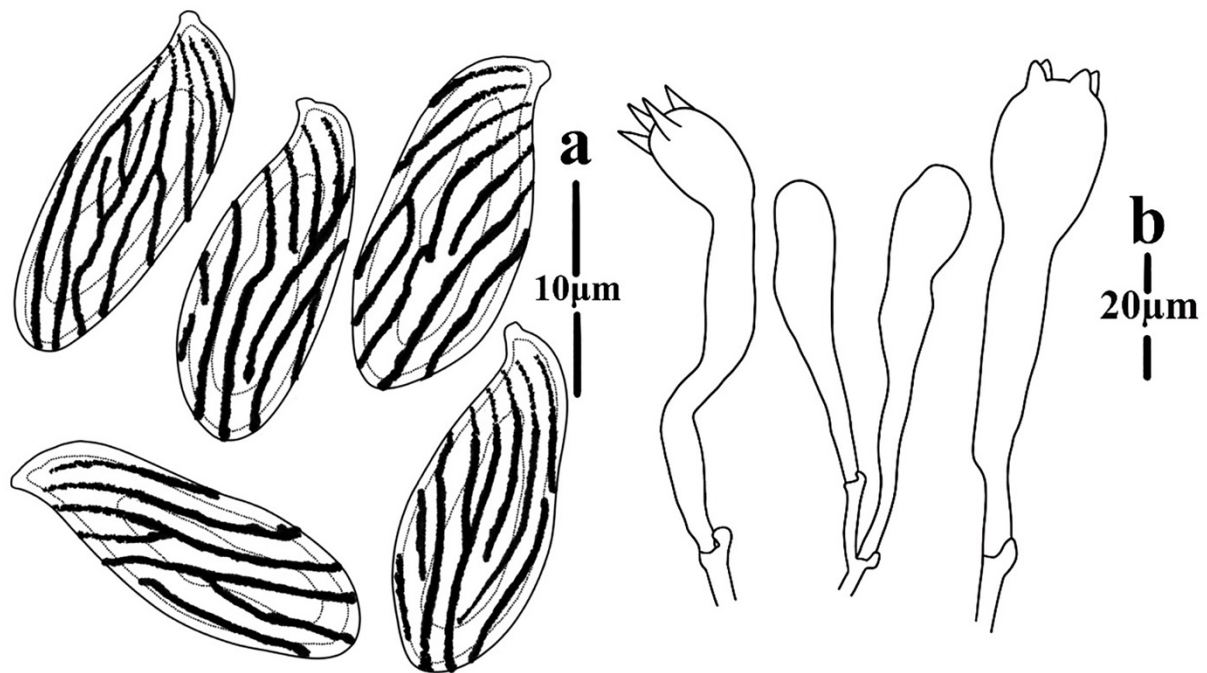


Fig. 45 Microscopic features of *R. sinobotrytis* (MHHNU 9268). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

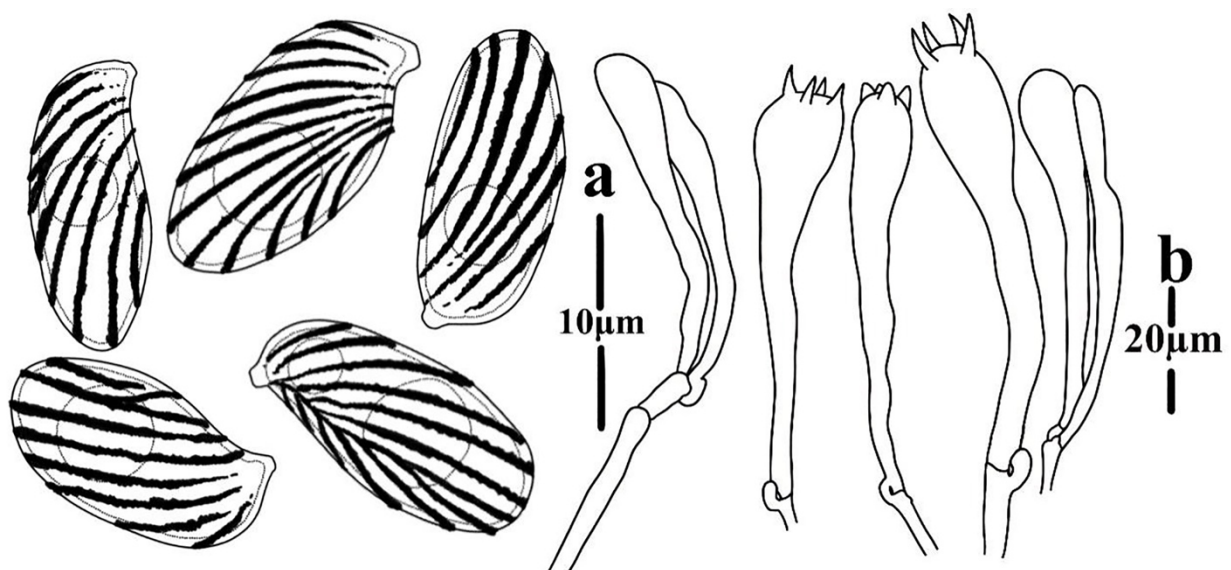


Fig. 46 Microscopic features *R. violaceoaurantia* (MHHNU 10074). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Ecology: Found in broad-leaved or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Sichuan).

Commentary: This species is similar to *R. botrytis*, whose basidiospores measure $14.2 \times 5.2 \mu\text{m}$ (Franchi & Marchetti 2021). Although only one specimen was collected, it includes two additional young basidiomata. Moreover, it features the largest basidiospores among current species within the genus *Ramaria*, making it easily distinguishable from others. Our phylogenetic analysis indicates that the species exhibits the closest phylogenetic distance to *R. botrytis*.

16. *Ramaria violaceoaurantia* P. Zhang & J. Zhong, **sp. nov.** Fig. 13 m–o and Fig. 46

MycoBank: MB 852939

Etymology: *violaceoaurantia* = *violacea* + *aurantia* = orange, proposed because this species has purple to orange color on the apices.

Diagnosis: The apices are wine to purple-orange in color, turning brown-yellow when bruised, basidiospores are ornamented with longitudinal striae, and hyphae and basidia base feature clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Waze Township, in *Picea* forest, altitude 3800 m, 1 September 2018, P. Zhang 3574 (Holotype, MHHNU 10074, GenBank Acc. No.: ITS = PP467115, nrLSU = PP493446, *tef1-α* = PP480340).

Description: *Basidiomata* 11–12 cm high and 10–16 cm broad, big-sized. *Stipe* stout, up to $2\text{--}4 \times 2\text{--}3 \text{ cm}$, single, falsely fasciculate, to compound-connate, smooth, with a few abortive branchlets, off-white (1A1) to cream (4A3), slowly turned to lemon yellow (3B8) to brownish yellow (5B3) where handled; flesh off-white (1A1), flesh to fibrous, drying soft, easily penetrated. *Major branches* several, indistinct. *Branches* in 2–4 ranks, short and crowded; grayish orange (6B5) to brownish yellow (6C8) upward, concolor with stipe below; axils narrow rounded; internodes all short. *Apices* short and crowded, to reddish lilac (14B4) to brownish yellow (6C8). Odor weakly fragrant; taste sweet.

Basidiospores $[60/2/2]12.0\text{--}16.0 \times 5.0\text{--}7.0(-8.0) \mu\text{m}$, $L_m = 14.35 \mu\text{m}$, $l_m = 5.83 \mu\text{m}$, $Q = (1.71\text{--})1.92\text{--}3.10(-3.20)$, $Q_m = 2.40 \pm 0.33$, subcylindrical, conspicuously striae in profile, strongly cyanophilous; *Basidia* $60\text{--}80 \times 8\text{--}13 \mu\text{m}$, clavate, clamped at base; sterigmata 1–4, mostly 4, 3–7 μm , stout and straight. *Hymenium* unthickening; *Subhymenium* rudimentary, hyphal. *Tramal hyphae of stipe* 6–12 μm wide, hyaline, conspicuously clamped, thin to thick-walled, interwoven, not agglutinated or adherent; ampulliform clamps up to 15 μm broad, usually not thick-walled; gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated or adherent, parallel and tightly interwoven; ampulliform clamps occasional, unornamented; gloeoplerous hyphae not observed.

Ecology: Found in broad-leaved or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Sichuan, Yunnan, Xizang).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Waze Township, in *Picea* forest, altitude 3800 m, 1 September 2018, P. Zhang 3578 (MHHNU 10078). YUNNAN PROVINCE: Lijiang City, Baisha Town, Yulong County, Yulong Snow Mountain, in broad-leaved forest, altitude 3760 m, 17 August 2019, Jian W. Liu

1765; same location, altitude 3805 m, 24 August 2019, Jian W. Liu 1797. XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3499 (MHHNU 9999), P. Zhang 3500 (MHHNU 10000), P. Zhang 3501 (MHHNU 10001), P. Zhang 3502 (MHHNU 10002).

Commentary: *Ramaria violaceoaurantia* is distinguished by its prominently orange apices. It resembles European species *R. parobotrytis* Franchi & M. Marchetti, North American *R. aurantiiramosa* Marr & D.E. Stuntz ($\equiv R. botrytis$ var. *aurantiiramosa*) Marr & D.E. Stuntz, and *R. rubripermanens* Marr & D.E. Stuntz. Among these similar species, *R. aurantiiramosa* also exhibits orange apices, but with slightly narrower basidiospores ($12\text{--}16 \times 4\text{--}6 \mu\text{m}$, $L_m = 13.5 \mu\text{m}$, $l_m = 4.7 \mu\text{m}$, $Q_m = 2.87$; Marr & Stuntz 1973; Franchi & Marchetti 2021, 2018). *Ramaria parobotrytis* and *R. rubripermanens* display more distinctly reddish-purple apices in maturity and have slightly smaller basidiospores. Although variability in basidiospores size exists within the *R. botrytis* complex, our molecular evidence indicates significant genetic divergence among these species, which are also geographically distant from each other.

Ramaria ser. Brunnescentiaurantiæ P. Zhang & J. Zhong, **ser. nov.**

MycoBank: MB 852731

Diagnosis: *Basidiomata* are pale orange to bright orange, with stipe, branches, and apices concolorous with each other. Bruised results in a purple-brown coloration. Hyphae and basidia base are nearly devoid of clamps.

Type species: *R. brunnescentiaurantiæ* P. Zhang & J. Zhong.

Etymology: *brunnescentiaurantiæ* = *brunescens* (turned to brown when injured) + *aurantiæ* (orange).

Commentary: This series comprises three species collected in China, in addition to other species found elsewhere including *R. amyloidea* Marr & D.E. Stuntz, *R. claviramulata* Marr & D.E. Stuntz (synonymous: *R. celerivirescens* Marr & D.E. Stuntz), *R. magnifica* Schild, and its variety *R. magnifica* var. *sardiniensis*.

17. *Ramaria aurantibrevispora* P. Zhang & J. Zhong, **sp. nov.** Fig. 14 a–b and Fig. 47

MycoBank: MB 853372

Etymology: *aurantibrevispora* = “*auranti-*” + “*brevispora*”, referring to the orange-colored basidiomata of the species and its short basidiospores.

Diagnosis: Small-sized basidiomata, yellowish orange to salmon-colored; short branches with yellow apices or concolorous with the branches; bruised turn grayish purple; occasional pseudo clamps in hyphae, with clamps absent at basidia base.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Nanhua County, Dazhongshan Forestry Farm, in a forest dominated by *Fagaceae*, altitude 2200m, 10 October 2021, Jian W. Liu 2549 (Holotype, MHHNU 11650, GenBank Acc. No.: ITS = PP599212, nrLSU = PP593674).

Description: *Basidiomata* 8–9 cm high and 5–5.5 cm broad, obtriangular to fusiform in outline. *Stipe* $1\text{--}4 \times 0.5\text{--}2 \text{ cm}$, single to falsely fasciculate, tomentose at base, pale orange (5A3) to salmon (6A4) color, turned to gray-lilac (15B2) when hurt. *Major branches* few, terete, slender, pale orange (5A3)

to salmon (6A4); flesh orange white (5A2). *Branches* in 3–5 ranks, ascending, terete, melon yellow (5A6) when young, pale orange (5A3) to salmon (6A4) at age; flesh more pallid, brittle to brittle-fibrous, gelatinous; internodes diminishing

gradually at maturity; axils narrowly rounded throughout. *Apices* are short and acute, double-dichotomous, concolorous with branches. Odor and taste faintly fabaceous.

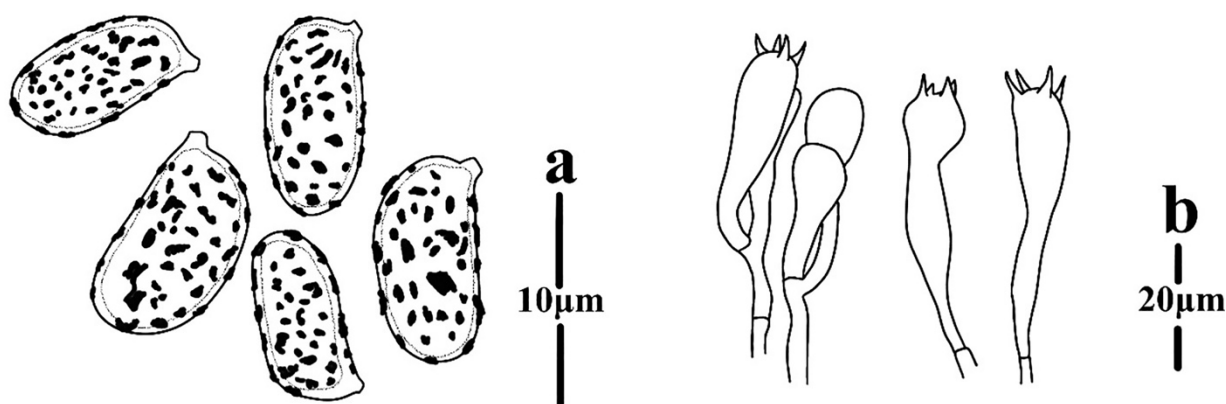


Fig. 47 Microscopic features of *R. aurantibrevispora* (MHHNU 11650). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [62/2/2] (7.2–)7.5–9.8(–10.6) × (3.7–)3.9–4.8(–5.2) μm, $L_m = 8.68$ μm, $l_m = 4.33$ μm, $Q = (1.65–)1.74–2.29(–2.42)$, $Q_m = 2.01 \pm 0.16$, subcylindrical to ellipsoid, slightly roughened in profile; hilar not prominent; ornamentation of small, randomly scattered flat warts. **Basidia** 30–45 × 7–19 μm, clavate, without clamps; sterigmata 4, long, slender, straight. **Subhymenium** extensive, hyphae. **Hymenium** unthickening. **Tramal hyphae of stipe** 5–17 μm wide, hyaline, without clamps, tightly interwoven, not agglutinated or adherent; ampulliform clamps up to 16 μm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** up to 4–15 μm wide, hyaline, thin walled, without clamped, loosely parallel, more inflated inward, agglutinated to adherent; ampulliform clamps up to 17 μm broad, gloeoplerous hyphae occasionally.

Ecology: Found in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 2 August 2001, P. Zhang 97 (MHHNU 6597); same location, Xianren Valley, in broad-leaved forest, altitude 2400 m, 24 August 2023, P. Zhang 5039 (MHHNU 11539); same city, Nanhua County, Dazhongshan Forestry Farm, in mixed broadleaf-coniferous forest, altitude 2314 m, 11 August 2017, Jian W. Liu 864 (MHHNU 11642).

Commentary: In our two-gene phylogenetic analysis, the species most closely related to *R. aurantibrevispora*, which has its type locality in Italy, are *R. magnifica* Schild, and its two variety, *R. magnifica* var. *magnifica* and var. *sardinian* (now called *R. sardiniensis*). They all share characteristics such as 1) absence clamps in hyphae and basidia base; 2) basidiospores average length less than 10 μm; 3) gray-purple bruised; 4) small to medium sized basidiomata with yellowish orange to salmon colors; 5) axils with narrow acute angles, V-shaped. *Ramaria magnifica* var. *magnifica* and *R. sardiniensis* differ in the former having larger basidiomata, more yellow-orange hues, and slightly larger basidiospores. However,

both of these species show molecular sequence differences from *R. aurantibrevispora*, with morphological distinctions being subtle, particularly in basidiospores size, where *R. aurantibrevispora* basidiospores have an average length of less than 9 μm.

In Dr. Zhang Ping's postdoctoral thesis (2010), this species is considered a variant of *R. cyaneigranosa*, a species described by Marr & Stuntz in the United States. *Ramaria cyaneigranosa* exhibits an intermediate color between red and salmon in its basidiomata, rough basidiospores surfaces, and intensely cyanophilic contents in basidia. *Ramaria cyaneigranosa* comprises three varieties: var. *cyaneigranosa* with yellow branch tips, var. *persicina* with pink or salmon-colored branches and yellow spots on the tips, and var. *elongata*. Morphologically, the basidiomata color and basidiospores size of *R. aurantibrevispora* from Zixi Mountain in Yunnan are indeed similar to *R. cyaneigranosa*, but they show distant molecular phylogenetic relationships.

Another species resembling *R. aurantibrevispora* is *R. brunnescentiaurantia*, both being small to medium sized with yellowish orange basidiomata. The distinguishing feature of *R. brunnescentiaurantia* is its longer basidiospores (10.35 × 5.13 μm, as measured in this study).

18. *Ramaria brunnescentiaurantia* P. Zhang & J. Zhong, **sp. nov.** Fig. 14 c–d and Fig. 48

Mycobank: MB 853235

Etymology: *brunnescentiaurantia* = “*brunnescenti*” + “*aurantia*”, referring to the species having red to orange basidiomata that turn brown when injured.

Diagnosis: Basidiomata are salmon to orange, with stipe or main branches elongated and concolorous with branches. Bruised results in a grayish purple coloration. Hyphae and basidia base are without clamps.

Type: CHINA, SICHUANG PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, 5 September 2021, P. Zhang 4272 (Holotype, MHHNU 10772, GenBank Acc. No.: ITS = PP467243, nrLSU = PP493552, *tef1-a* = PP480418).

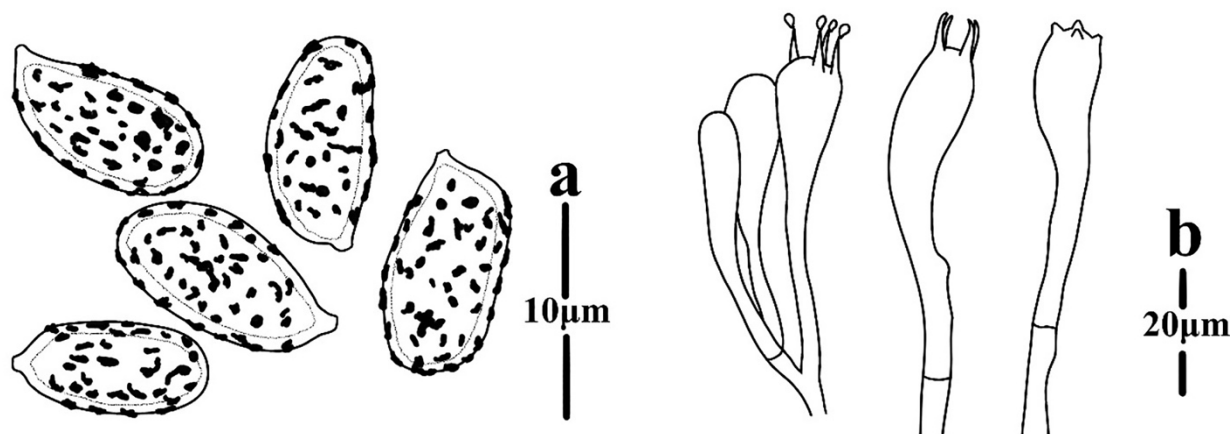


Fig. 48 Microscopic features of *R. brunnescentiaurantia* (MHHNU 10772). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Description: *Basidiomata* 10.5 cm high and 8 cm broad, linear, long fusiform in outline. *Stipe* 1.4 × 2 cm, fasciculate or with a very small point of union at the base, or solitary, smooth, pale orange (5A3) to salmon (6A4), turned to brownish violet (11F8) when hurt. *Major branches* 2–4, ascending, terete, pale orange (5A3) to salmon (6A4); flesh white (1A1) to pallid orange (5A2) near hymenium; *Branches* in 3–5 ranks, ascending, more or less terete, pale orange (5A3) to salmon (6A4); flesh more pallid, brittle to brittle-fibrous, more or less gelatinous; internodes diminishing gradually at maturity; axils narrowly rounded throughout, "V" shaped. *Apices* broadly rounded, double-dichotomous, concolorous with branches. Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (8.8–)9.1–11.2(–11.9) × (4.3–)4.6–5.9(–6.3) μm, $L_m = 10.35$ μm, $l_m = 5.13$ μm, $Q = (1.68–)1.81–2.23(–2.42)$, $Q_m = 2.02 \pm 0.14$, ellipsoid, slightly roughened in profile; hilar prominent; ornamentation of small, randomly scattered flat warts. *Basidia* 40–55 × 6–10 μm, clavate, without clamps; sterigmata 4, long, slender, curved. *Subhymenium* extensive, hyphae. *Hymenium* unthickening. *Tramal hyphae* of *stipe* 6–15 μm wide, hyaline, without clamps, loosely parallel, not agglutinated or adherent; ampulliform clamps up to 17 μm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae* of *upper branches* up to 5–15 μm wide, hyaline, thin walled, without clamped, loosely parallel, more inflated inward, more or less agglutinated to adherent; ampulliform clamps up to 18 μm broad, gloeoplerous hyphae occasionally.

Ecology: Found in broad-leaved, coniferous, or mixed forests. *Basidiomata* occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La City, Haba Snow Mountain, Mianshaba, altitude 3100 m, 10 August 2008, Li-P. Tang 619 (HKAS 54850). SICHUANG PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4375 (MHHNU 10875); same location, altitude 3900 m, 6 September 2021, P. Zhang 4293 (MHHNU 10293), P. Zhang 4294 (MHHNU 10294), P. Zhang 4309 (MHHNU 10309), P. Zhang 4312 (MHHNU 10312).

Commentary: *Ramaria brunnescentiaurantia* closely resembles to *R. aurantibrevispora* (basidiospore 8.68 × 4.33 μm, as measured in this study), as both species have yellowish orange basidiomata, non-clamped hypha and

basidia, stain purplish-gray upon injury. However, *R. brunnescentiaurantia* is distinguished by its longer basidiospores and typical inhabit in high-altitude regions.

Distinguishing *R. brunnescentiaurantia* from *R. magnifica* and its variants primarily involves slight differences in basidiospores length. In Zhang's 2010 postdoctoral thesis (Zhang 2010), it is proposed that *R. brunnescentiaurantia* may be synonymous with *R. cyaneigranosa* var. *elongata*. However, this species exhibits only moderate cyanophilous reaction within its basidia.

19. *Ramaria verrucosiflava* P. Zhang & J. Zhong, sp. nov. Fig. 14 e–f and Fig. 49

Mycobank: MB 853191

Etymology: *verrucosiflava* = *verrucosus* + *flava*, proposed because this species has fine warts basidiospores and orange-yellow basidiomata.

Diagnosis: *Basidiomata* salmon to orange yellow; basidia and hyphae with clamps; basidiospores small sized and finely warty; apices yellow.

Type: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3408 (Holotype, MHHNU 9908, GenBank Acc. No.: ITS = PP467288, nrLSU = PP493590, *tef1-α* = PP480448).

Description: *Basidiomata* 10 cm high and 6 cm broad, medium sized. *Stipe* 3 × 3 cm, single to falsely fasciculate, tapering gradually downward, smooth, off-white (1A1) to melon yellow (5A6), with occasional abortive branchlets; flesh solid, off-white (1A1) to orange white (5A2), moist, but not gelatinous or slippery. *Major branches* several, stout and short, terete, ascending, concolorous with stipe downward, concolorous with branches upward, not changing color on bruising. *Branches* in 3–4 ranks, dichotomous, terete, ascending, orange white (5A2) to melon yellow (5A6); flesh pale orange (5A3), soft; internodes length ratio diminishing gradually at maturity; axils mostly acute, both U-shaped and V-shaped. *Apices* crowded, double dichotomous, vivid yellow (2A8) to yellowish orange (4A8); Odor faintly penetrating; taste negligible.

Basidiospores [22/2/2] (7.4–)8.0–8.9(–9.3) × (2.8–)3.1–3.8(–3.9) μm, $L_m = 8.59$ μm, $l_m = 3.61$ μm, $Q = 2.16–2.82(–3.16)$, $Q_m = 2.39 \pm 0.23$, ellipsoid, nearly smooth in profile; hilar appendix prominent; ornamentation finely or or extremely obscurely undulate in profile. *Basidia* 40–55 × 7–11 μm, clavate, clamped; sterigmata 4, long, spindly, straight.

Subhymenium rudimentary, pseudoparenchymatous. *Hymenium* thickening. *Tramal hyphae* of stipe 4–12 µm wide, usually inflated, hyaline, thin- to thick walled, loosely parallel, interwoven, not agglutinated or adherent; ampulliform clamps up to 23 µm broad, thick-walled, with coarse ornamentation; gloeoplerous hyphae not observed; *Tramal hyphae* of upper

branches up to 3–14 µm wide, hyaline, thin-to thick-walled, clamped, secondarily septum, loosely parallel, not agglutinated or adherent; ampulliform clamps up to 22 µm broad, thick-walled, unornamented; gloeoplerous hyphae not observed.

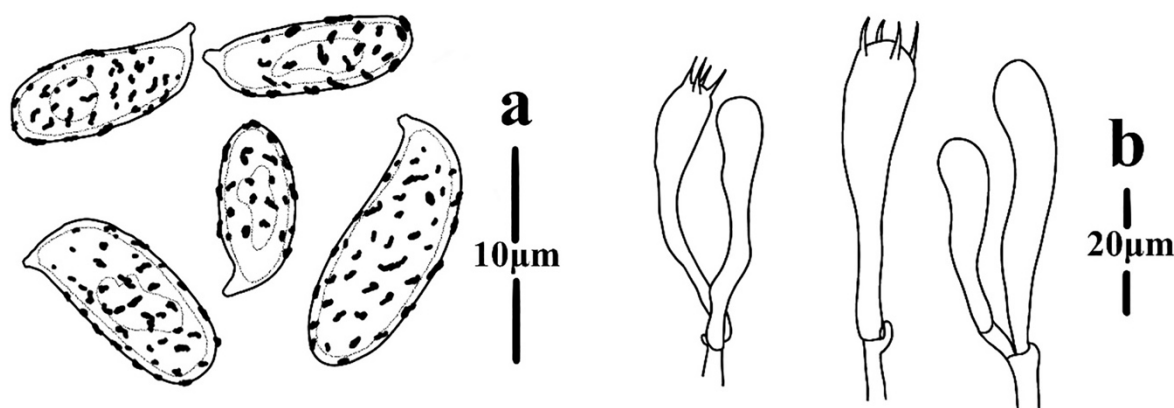


Fig. 49 Microscopic features of *R. verrucosiflava* (MHHNU 9908). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Ecology: Found in broad-leaved forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3404 (MHHNU 9904), P. Zhang 3419 (MHHNU 9919), P. Zhang 3420 (MHHNU 9920); Qujing City, Qilin District, near Longyuan Zhumushan Wind Farm, in broad-leaved forest, altitude 2250 m, 19 August 2022, P. Zhang 4706 (MHHNU 11206); Chuxiong, Zixi Mountain, in mixed forests dominated by Fagaceae and Pinaceae, altitude 2250 meters, 24 August 2022, P. Zhangping 4784 (MHHNU 11284).

Commentary: *Ramaria verrucosiflava* bears a strong resemblance to *R. amyloidea* (basidiospore 8.9×3.6 µm, Marr & Stuntz 1973). Both species feature similarly sized and nearly smooth basidiospores, along with clamped basidia and hyphae. However, *R. amyloidea* is characterized by a distinctive flesh band of pale brown hyphae visible in the basal region of a radially sectioned stipe and amyloid flesh. Our two-gene phylogenetic analysis indicates a close relationship between these species, confirming their distinct taxonomic identities despite their similarities.

Ramaria* ser. *Conjunctipesae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852741

Etymology: “*conjunc*” derives from “joined”, and “-*ipes*” from “foot”, “*conjunctipes*” refers to the stipe base being joined together.

Type species: *R. conjuncta* (Peck) Corner, Monograph of *Clavaria* and allied Genera, (Annals of Botany Memoirs No. 1): 566 (1950)

Diagnosis: Gregarious habit; basidiomata are small to medium sized, ranging in color from salmon, yellow to pallid orange; stipe flesh is tough; basidiospores are small and broadly ($L_m < 10$ µm), small warty; hyphae and basidia lack clamps; no color change upon bruising.

Commentary: This series includes four species collected

in China. Additional species found elsewhere include *R. orithamnus* (Berk.) R.H. Petersen, *R. ignicolor* Corner, *R. conjunctipes* (Coker) Corner and its varieties *R. conjunctipes* var. *tsugensis* Marr & D.E. Stuntz, and *R. conjunctipes* var. *sparsiramosa* Marr & D.E. Stuntz.

20. *Ramaria flaviaggregata* P. Zhang & J. Zhong, **sp. nov.** Fig. 15 a–b and Fig. 50

Mycobank: MB 853299

Etymology: *flaviaggregata* = *flava* + *aggregate*, referring to the species having pale yellow-colored basidiomata and a fasciculate habit.

Diagnosis: Basidiomata are small to medium sized and pastel yellow in color; apices are dichotomous, ranging from yellow to pale yellow; basidiospores are small and broadly, slightly roughened; flesh of the stipe and branches is fleshy-fibrous, turning to brownish yellow when bruised; hyphae and basidia base lack clamps.

Type: CHINA, HUNAN PROVINCE: Chenzhou City, Rucheng County, Daping Town, Jiulongjiang National Forest Park, in broad-leaved forest, altitude 100 m, 2 October 2020, P. Zhang 4065 (Holotype, MHHNU 10565, GenBank Acc. No.: ITS = PP467224, nrLSU = PP493538).

Description: Basidiomata 8–10 cm high and 4–6 cm broad, coralline form, fasciculate habit. Stipe 3×1.5 cm, individual stipes cluster together at base, or branching directly from the ground; off-white at base (1A1), surface pale yellow (2A3) to cream (4A3) upward; slightly changing color to brownish yellow (5B3) on bruising; surface tomentose or longitudinally gnarled and rugose; occasionally with abortive branches; context of stipe off-white (1A1) when fresh, fleshy-fibrous, occasionally hollow, drying hard, cartilaginous. Branches in 4–5 ranks, major branches 4–several, commonly polychotomous, branches above mostly dichotomous; cream (4A3) to butter yellow (4A5) when young, pale yellow (2A3) to pastel yellow (2A4) at age; axils broadly rounded, mostly U-shaped, mostly bifid near apices; internodes diminishing gradually at maturity, lower internodes up to 5 cm; branches slender, commonly 3–8 mm, terete, subparallel; context of main

branches and upper branches freshy-fibrous, off-white (1A1), slightly changing color to brownish yellow (5B3) on bruising. *Apices* acute, short, claw-like, 1–4 mm long, dichotomous,

butter yellow (4A5) when young, turned to pall yellow (2A3) at age, the tips slightly brownish yellow (5B3) or concolorous with branches. Odor and taste faintly fabaceous.

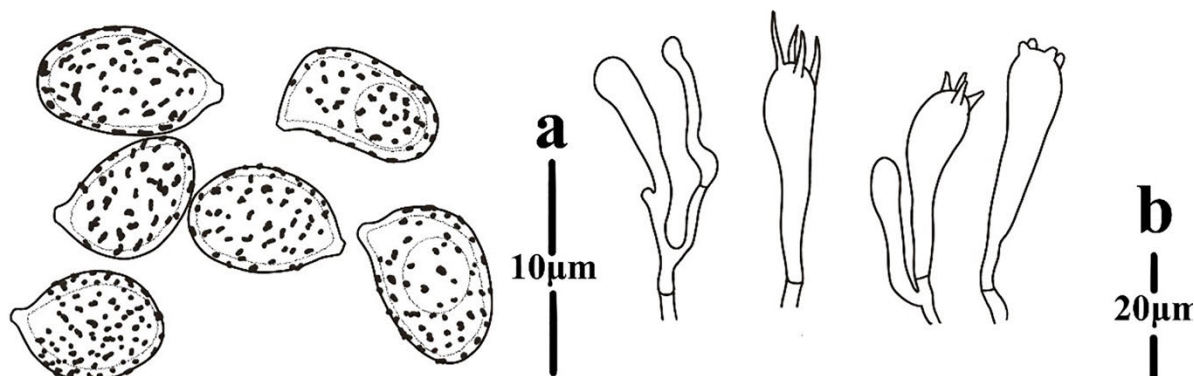


Fig. 50 Microscopic features of *R. flaviaggregata* (MHHNU 10565). a basidiospores; b basidia, a = 10 µm, b = 20 µm

Basidiospores [60/2/2] (6.0–)6.5–8.9(–9.6) × (4.2–)4.5–5.7(–6.1) µm, $L_m = 7.55$ µm, $l_m = 5.05$ µm, $Q = (1.20\text{--})1.30\text{--}1.68$ (–1.81), $Q_m = 1.50 \pm 0.14$, ovate to shortly ellipsoidal; finely ornamented with linearly lobed, cyanophilous warts; hilar appendix small but conspicuous. **Basidia** 30–45 × 5–9 µm, clavate, without clamps at base; sterigmata 2–4, mostly 4, 5–9 µm long, incurved or straight, slightly divergent. **Hymenium** unthickening, 50 µm. **Subhymenium** extensive, 10–30 µm thick, hyphae, interwoven, 2–5 µm diam, thin-walled, without clamps. **Contextual hyphae**: Tramal hyphae of stipe 5–11 µm wide, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 13 µm, with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 12 µm, with smooth and thin wall; ampulliform hyphae rarely; without clamps; gloeoplerous hyphae occasionally.

Ecology: Found in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern and central China (Yunnan, Hunan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Xishuangbanna City, Menglun Town, near Kino Gully, in the *Castanopsis* forest on the ridge, altitude 1000 m,

14 August 2005, P. Zhang 452 (MHHNU 6952), P. Zhang 454 (MHHNU 6954); same city, bought from mushroom market, 11 October 2006, P. Zhang 583 (MHHNU 7083); Kunming City, Near Qiongzhu Temple, altitude 1900 m, 26 July 2011, Nian K. Zeng 929 (FUMU 570).

Commentary: The geographic distribution of *R. flaviaggregata* is extensive, ranging from the southwest to the central China. It belongs to the *R. conjunctipes* complex group, but its coloration sets it apart within this group. Unlike the pink to salmon hues observed in *R. conjunctipes* or mustard yellow of *R. lorithamnus*, *R. flaviaggregata* exhibits a distinctive off-white to pale yellow color. *Ramaria pallidoflava* is similar in color and basidiospores size (7.57×5.15 µm, as measured in this study), making differentiation challenging. Subtle distinctions include *R. flaviaggregata* having lower axils for the stipe, a slender stipe, and a slightly more browning color on bruising.

21. ***Ramaria microsporoflava*** P. Zhang & J. Zhong, *sp. nov.* Fig. 15 c–d and Fig. 51

Mycobank: MB 853296

Etymology: “*microsporoflava*” refers to the species being yellow colored with small basidiospores.

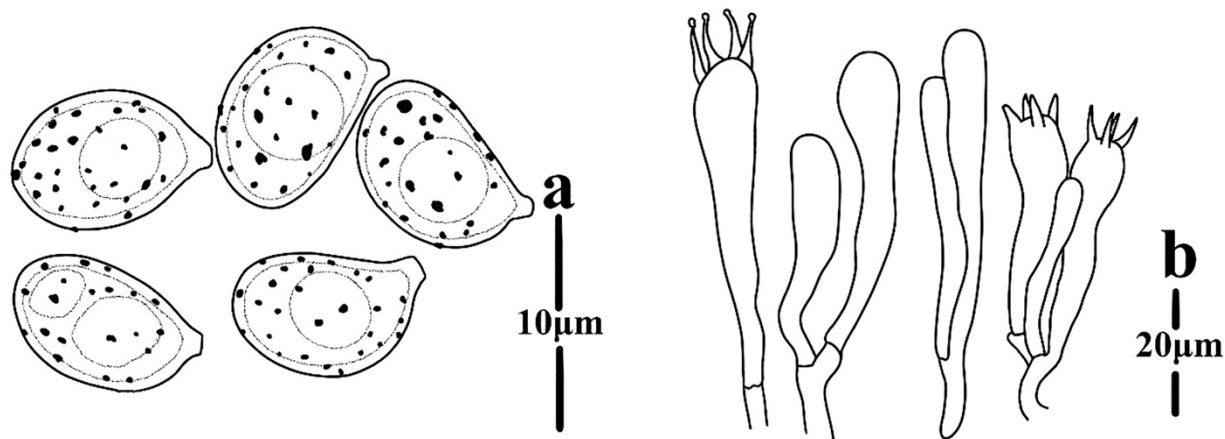


Fig. 51 Microscopic features of *R. microsporoflava* (MHHNU 31326). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Diagnosis: Basidiomata are small, ranging from salmon to pallid orange in color; apices are vivid yellow colored; basidiospores are small and broadly, ovate to shortly ellipsoidal, and nearly smooth; The color does not change upon bruising; hyphae and basidia base lack clamps.

Type: CHINA, YUNNAN PROVINCE: Mouding County, Huafo Mountain, altitude 2500 m, 23 August 2018, Zuo H. Chen 31326 (Holotype, MHHNU 31326, GenBank Acc. No.: ITS = PP467216, nrLSU = PP493530).

Description: *Basidiomata* 4–6 cm high and 0.3–2.5 cm broad, usually shrubby with a fasciculate habit. *Stipe* 0.3–2 × 0.5 cm, rarely single, usually fasciculate, tapering gradually downward; off-white (1A1) at base, pale yellow (2A3) to pale orange (5A3) above; not changing color on bruising; covered with a white tomentum where buried in the substratum; without abortive branches; context of stipe off-white (1A1), freshly-fibrous, more or less gelatinous when fresh, occasionally hollow, drying brittle and with distinct chalky-friable properties. *Branches* in 3–6 ranks, major branches commonly polychotomous, and branches above dichotomous, elongated, slightly divergent; cream (4A3) when young, salmon to butter yellow (6A4–4A5) at age; axils acute to V-shaped, mostly bifid near apices; internodes diminishing gradually at maturity, lower internodes up to 2 cm; branches slender, commonly 3–9 mm, seldom over to 2 cm, terete to flattened, compact and subparallel; context of main branches freshly-fibrous, off-white (1A1), context of upper branches freshly-fibrous, more or less gelatinous, pall orange (5A3), bruising or staining reactions slight or entirely absent. *Apices* acute, crowded, dichotomous, vivid yellow (2A8). Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (6.6–)7.4–9.2(–9.5) × (4.4–)4.8–6.2(–6.5) μm , $L_m = 8.25 \mu\text{m}$, $l_m = 5.43 \mu\text{m}$, $Q = (1.28\text{--})1.35\text{--}1.70(1.82)$, $Q_m = 1.52 \pm 0.11$, ovate to shortly ellipsoidal; finely ornamented with linearly lobed, cyanophilous warts; hilar appendix small but conspicuous. *Basidia* 35–50 × 7–11 μm , clavate, without clamps; sterigmata 1–4, mostly 4, irregular, 5–10 μm long, incurved or straight, slightly divergent, occasionally two sterigmata connate at base. *Hymenium* unthickening. *Subhymenium* extensive, 25–30 μm thick, hyphae, interwoven, 3–5 μm diam, thin-walled, without clamps. *Contextual hyphae*: parallel to subparallel in both base and branches, not-inflating or inflating slightly, up to 4–12 μm wide; outer hyphae of the stipe collapsing and forming a densely stratified parallel tissue, somewhat cornenous; the central context of both stipe and branches lysing, hyphae

walls frequently undulate, mostly smooth and slightly gelatinized, thin to moderately thick-walled, strongly cyanophilous; ampulliform hyphae rarely, 8–13 μm , nearly smooth; without clamps; gloeoplerous hyphae uncommon, mostly of narrow diam, 2–3 μm .

Ecology: Found in broad-leaved and coniferous mixed forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan).

Additional material examined: CHINA, YUNNAN PROVINCE: Binchuan County, Jizu Mountain, with broad-leaved, coniferous, or mixed forests, altitude 2300 m, 29 August 2022, P. Zhang 4813 (MHHNU 11313).

Commentary: The species most similar to *R. microsporoflava* is *R. ignicolor* Corner. Corner described *R. ignicolor* as having non-inflated hyphae without clamps and firmly gelatinous walls. Franchi notes that *R. ignicolor* is easily distinguished among yellow to orange *Ramaria* species due to its unique macroscopic and microscopic characteristics: the branches are usually hollow, the hyphae lack clamps, and they possess gelatinous hyphae.

The basidiomata of *R. microsporoflava* (4–6 × 0.6–2.5 cm) is smaller than those of *R. ignicolor* described by Franchi (13 × 4–7 cm) (2021) and more akin to the dimensions reported by Corner from Bresadola's records (height 4 cm) (1950). Although the average basidiospores length ($L_m = 8.25 \mu\text{m}$) is slightly longer than that described by Franchi ($L_m = 7.9 \mu\text{m}$), the basidiospores width is similar ($l_m = 5.43 \mu\text{m}$), being slightly larger than the dimensions provided by Corner (7–8.5 × 4–5 μm). Despite minimal differences in basidiospores size, significant differences exist in basidiomata coloration. The Latin term "*ignicolor*" denotes a fiery red color. Although Corner did not collect this species, observations of dried specimens indicate a light orange-ochraceous color, suggesting that fresh basidiomata may also be darker. In contrast, *R. microsporoflava* tends to exhibit yellow to salmon colors when fresh, transitioning to a light leather yellow when dried specimens. Franchi's color illustrations confirm that the Italian-described *R. ignicolor* indeed possesses a more vibrant orange hue, with a higher degree of gelatinization in both the stipe and branch flesh.

22. *Ramaria pallidoflava* P. Zhang & J. Zhong, **sp. nov.** Fig. 15 e–f and Fig. 52

Mycobank: MB 853297

Etymology: *pallidoflava* = *pallidus* + *flava*, referring to the species having pall yellow-colored basidiomata.

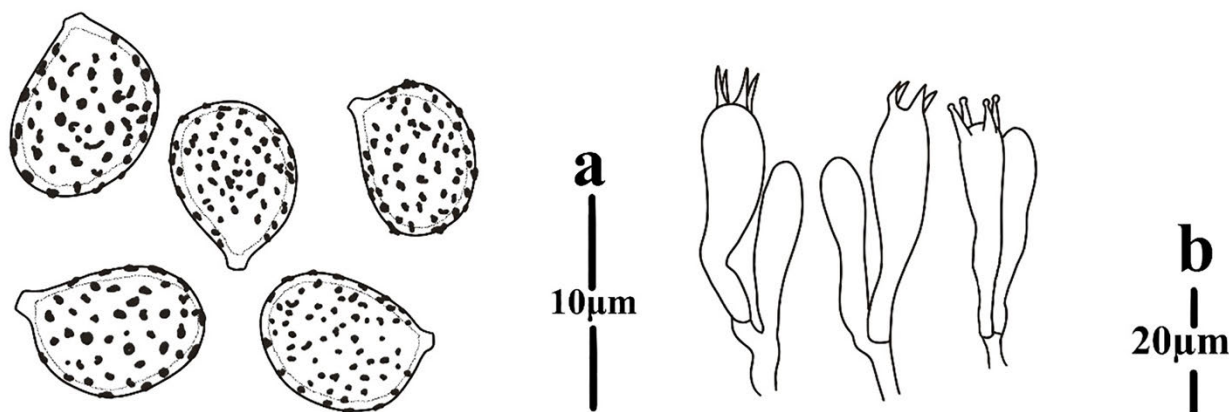


Fig. 52 Microscopic features of *R. pallidoflava* (MHHNU 11652). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Diagnosis: Basidiomata are small to medium sized and pallid yellow in color; apices are dichotomous, ranging from yellow to pallid yellow; basidiospores are small and broadly, slightly roughened; flesh of stipe and branches is freshy-fibrous, turning brownish yellow when bruised; hyphae and basidia base lack clamps.

Type: CHINA, YUNNAN PROVINCE: Nanhua County, Dazhongshan Forestry Farm, in a forest dominated by Fagaceae, altitude 2400 m, 11 October 2021, Jian W. Liu 2576 (Holotype, MHHNU 11652, GenBank Acc. No.: ITS = PP467223, nrLSU = PP493537).

Description: *Basidiomata* 14 cm high and 10 cm broad, usually single to fasciculate habit. *Stipe* 2 × 5 cm, terete when young, flatten due to hollow flesh at maturity, clustered together at base; off-white at base (1A1), surface pale yellow (2A3) to cream (4A3) upward; slightly changing color to brownish yellow (5B3) on bruising; surface tomentose or longitudinally gnarled and rugose; occasionally with abortive branches; context of stipe off-white (1A1) when fresh, freshy-fibrous, occasionally hollow, drying hard, cartilaginous. *Branches* in 3–5 ranks, major branches commonly polychotomous, cluster below, branches above mostly dichotomous; cream (4A3) when young, pale yellow (2A3) to pastel yellow (2A4) at age; axils broadly rounded, mostly U-shaped, mostly bifid near apices; internodes diminishing gradually at maturity, lower internodes up to 4 cm; branches slender, commonly 3–10 mm, terete or flattened, crowded, subparallel; context of main branches and upper branches freshy-fibrous, off-white (1A1), bruising or staining reactions entirely absent. *Apices* acute, short, 1–4 mm long, dichotomous, concolorous with branches. Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (6.7–)6.9–8.6(–8.8) × (4.4–)4.5–6.3(–6.6) μm , $L_m = 7.57 \mu\text{m}$, $l_m = 5.15 \mu\text{m}$, $Q = (1.25\text{--})1.32\text{--}1.66(1.78)$, $Q_m = 1.47 \pm 0.11$, ovate to shortly ellipsoidal; finely ornamented with linearly lobed, cyanophilous warts; hilar appendix small but conspicuous. *Basidia* 35–45 × 6–11 μm , clavate, without clamps at base; sterigmata 2–4, mostly 4, 3–6 μm long, incurved or straight, slightly divergent. *Hymenium* unthickening, 50 μm . *Subhymenium* extensive, 10–20 μm thick, hyphae, interwoven, 2–5 μm diam, thin-walled, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 6–13 μm wide, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 14 μm , with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 13 μm , with smooth and thin wall; ampulliform hyphae rarely; without clamps; gloeoplerous

hyphae occasionally.

Ecology: Found in a broad-leaved forest. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern and central China (Yunnan, Hunan, Hubei).

Additional materials examined: CHINA, HUNAN PROVINCE: Zhangjiajie City, Sangzhi County, Badagong Mountain National Nature Reserve, Tianping Mountain, in a broad-leaved forest, altitude 1400 m, 27 July 2022, Zuo H. Chen 33498 (MHHNU 33498). HUBEI PROVINCE: Enshi, Hefeng County, Wuyang Township, Hewan Village, altitude 1000 m, 24 September 2019, Zuo H. Chen 31726 (MHHNU 31726).

Commentary: *Ramaria pallidoflava* belongs to the *R. conjunctipes* complex. Distinguished by its coloration, which resembles that of *R. flaviaggregata*, it leans towards a pale-yellow hue. Within the *R. conjunctipes* complex, apart from *R. lorithamnus*, most species exhibit ranging from pink to salmon. *Ramaria pallidoflava* and *R. flaviaggregata* (basidiospore 7.55 × 5.05 μm , as measured in this study) share similar coloration and basidiospores size, making differentiation challenging, with subtle distinctions such as the higher axils of the stipe in *R. pallidoflava* and a stouter stipe.

23. *Ramaria sinoconjunctipes* R.H. Petersen & M. Zang, Acta bot. Yunn.12(1): 50, 1990. Fig. 15 g–h and Fig. 53

Description: *Basidiomata* 6–8 cm high and 2–3 cm broad, usually shrubby with a fasciculate habit. *Stipe* 1–2 × 2–5 cm, rarely single, clustered together at base, flatten due to hollow flesh, or branching directly from the ground; off-white at base, pale yellow to pale orange above; not changing color on bruising; surface nearly smooth; without abortive branches; context of stipe off-white, freshy-fibrous, more or less gelatinous when fresh, occasionally hollow, drying cartilaginous. *Branches* in 3–6 ranks, major branches commonly polychotomous, and branches above dichotomous; cream when young, salmon to butter yellow at age; axils acute to U-shaped, mostly bifid near apices; internodes diminishing gradually at maturity, lower internodes up to 4 cm; branches slender, commonly 3–6 mm, seldom over to 1 cm, terete, crowded, subparallel; context of main branches freshy-fibrous, off-white, context of upper branches freshy-fibrous, more or less gelatinous, pall orange, bruising or staining reactions slight or entirely absent. *Apices* acute, 1–3 mm long, crowded, dichotomous, vivid yellow. Odor and taste faintly fabaceous.

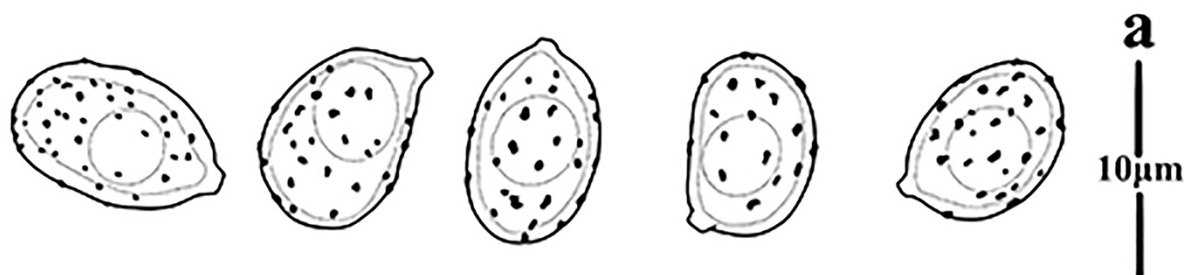


Fig. 53 Basidiospore features of *R. sinoconjunctipes* (MHHNU 11645). Scale bar: a = 10 μm

Basidiospores [60/2/2] (6.6–)7.0–9.0(–9.7) × (4.1–)4.3–6.1(–6.3) μm , $L_m = 7.13 \mu\text{m}$, $l_m = 5.17 \mu\text{m}$, $Q = (1.27\text{--})1.32\text{--}1.74(1.86)$, $Q_m = 1.51 \pm 0.31$, ovate to shortly ellipsoidal; finely ornamented with linearly lobed, cyanophilous warts; hilar

1.86), $Q_m = 1.51 \pm 0.31$, ovate to shortly ellipsoidal; finely ornamented with linearly lobed, cyanophilous warts; hilar

appendix small but conspicuous. *Basidia* 40–50 × 7–12 µm, clavate, without clamps at base; sterigmata 2–4, mostly 4, 3–6 µm long, incurved or straight, slightly divergent, occasionally two sterigmata connate at base. *Hymenium* unthickening, 55 µm. *Subhymenium* extensive, 25–30 µm thick, hyphae, interwoven, 2–5 µm diam, thin-walled, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 4–9 µm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 13 µm, with moderately ornamented; tramal hyphae of branches up to 2–6 µm wide, central hyphae slightly lysing, terminal swollen hyphae wide to 12 µm, with smooth and thin wall; ampulliform hyphae rarely; without clamps; gloeoplerous hyphae occasionally.

Ecology: Found in a coniferous mixed forest. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, Black-White Water, 7 September 1983, Petersen 47274 (isotype, HKAS 20064); same city, Yulong County, Yulong Snow Mountain, altitude 3700 m, 25 July 2017, P. Zhang 2795 (MHHNU 9295); same location, 2019; same city, Baisha Township, Lijiang Alpine Botanical Garden, altitude 3569 m, 29 September 2019, Jian W. Liu 2029 (MHHNU 11645); Chuxiong, Nanhua County, Dazhongshan Forestry Farm, in a forest dominated by Fagaceae, altitude 2356 m, 10 October 2021, Jian W. Liu 2425 (MHHNU 11649); Deqin County, Baima Snow Mountain Nature Reserve, in *Picea* forest, altitude 3750 m, 17 August 2018, P. Zhang 3440 (MHHNU 9940), P. Zhang 3444 (MHHNU 9944), P. Zhang 3454 (MHHNU 9954).

Commentary: The isotype specimens HKAS17873 (*R. distinctissima*) and HKAS17855 (*R. rubriattenuipes*), both identified by Petersen in 1989, were incorrectly assigned. Only the isotype specimen HKAS20064 of *R. sinoconjunctipes* was correctly identified. This taxonomic complex is characterized by basidiomata with fasciculate, attenuate stipes, hyphae without clamps, short and wide basidiospores. The fruiting bodies of most included taxa exhibit pink to salmon branches and yellow apices, but *R. lorithamnus* has basidiomata that are yellow ochre all over. Among those with a salmon to yellow color pattern, only *R. ignicolor* is found in Europe.

Marr & Stuntz's (1973) concept of *R. conjunctipes* was probably not contain with typical material from eastern North American. They described branches as hollow and flesh as watery-gelatinous, characteristics not typical of eastern North American specimens. While this might seem like a minor distinction, the flesh in *R. sinoconjunctipes* is not gelatinous (microscopically hyphae are not agglutinated or adherent), but rather watery-hydrophanous. It is this quality, not gelatinization, that distinguishes it. Petersen also did not recall seeing gelatinous flesh in those taxa, although hollow branches are commonly observed.

Sharda (1983) and Thind (1985b) described their concept of *R. conjunctipes* from the eastern Himalayas. They noted fruitbody colors as "light salmon to salmon yellow colored, tips light yellow" and provided basidiospores dimensions of 7–8.5(–9.5) × 4–5(–5.5) µm. Their concept likely corresponds to *R. sinoconjunctipes*, with the only differing feature being the presence of sclerotic basidia in the Himalayan specimens, which was not observed in Petersen's collections.

Also considered part of this taxonomic complex is *R. petersenii* K.S. Thind & Sharda (1985b). The fruiting bodies are characterized by very sparse branching, with a long,

single, slender stipe that is not fasciculate. Basidiospores are wide (7–11.5 × 5–6.5 µm), and septa lack clamps. The color of the fruiting bodies was described as "orange, white to light orange in the central part, with pale orange apices."

Wu has described *R. hypogaea* Q.X. Wu (Wu 1987), whose basidiomata display fasciculate single stipes and a stature similar to *R. sinoconjunctipes*. However, the fruitbody coloration of *R. sinoconjunctipes*, becoming increasingly orange towards the apices. Despite these differences, *R. hypogaea* certainly belongs to the same taxonomic complex as *R. sinoconjunctipes*.

Ramaria ser. Flavae (Franchi & M. Marchetti) P. Zhang & J. Zhong, **stat. nov.**

Fungi Non Delineati, Raro vel Haud Perspecte et Explorate Descripti aut Definite Picti 16: 26 (2001)

Synonym: *Ramaria* sect. *Flavae* Franchi & M. Marchetti

Type species: *Ramaria flava* (Schaeff.) Quél., Fl. mycol. France (Paris): 466 (1888).

Diagnosis: Basidiomata range from pale yellow to dark yellow; frequently brunnescent or rubribrunnescent; basidiospores are often smooth or finely warty; 4) hyphae may be clamped or clampless.

Commentary: This series includes six species collected in China, as well as additional species such as *R. obtusissima* (Peck) Corner, *R. pseudoflava*, *R. flava*, *R. barenthalensis*, *R. edwinii*, *R. magnipes*, *R. rasilispora*, and its variety *R. rasilispora* var. *rasilispora*, as well as *R. sanguinea*. Here are the characteristics of some species within this series:

(1) *R. highlandensis* Petersen: The basidiomata primarily yellow to yellow-brown colors, with bright yellow apices; browning on bruising; Relatively pronounced aromatic odor, especially when the flesh is exposed. Basidiospores measure 11.5–13.7 × 4.0–4.7 µm ($Q = 2.67$ – 3.27 , $Q_m = 2.95$, $L_m = 12.43$ µm), and the type specimen from the United States.

(2) *R. magnipes* Marr & D.E. Stuntz and its varieties (*R. magnipes* var. *magnipes* Marr & D.E. and *R. magnipes* var. *albidior* R.H. Petersen): This species emerges in spring and features cauliflower-like basidiomata with a yellowish-green hue. The stipes are stout, and the basidiospores measure 11.8 × 3.7 µm. Clamps are present.

(3) *R. rasilispora* Marr & Stuntz and its varieties (*R. rasilispora* var. *rasilispora* Marr & D.E. Stuntz, and *R. rasilispora* var. *scatesiana* Marr & D.E.): This species appears in spring, with basidiomata ranging from light yellow to ochre-yellow. The basidiospores are smaller than 11 µm, and clamps are present.

(4) *R. rasilisporoides* Exeter: This species is relatively large cauliflower-like basidiomata, up to 28 × 20 cm. They are light yellow to pale orange in color. The stipe's flesh has a strong amyloid reaction. Basidiospores measure 9.1 × 3.6 µm, and clamps are present. The type specimen of originates from North America.

Additionally, Corner and others considered *R. obtusissima* (Peck) Corner to be a species with smooth basidiospores. Its basidiomata ranges from white to buff-yellow or ochraceous, and clamps are present. The type specimen of originates from North America. When Corner reorganized the species in 1950, it was considered a mixed group with smooth basidiospores. Petersen reexamining the type specimen in 1967, also noted the basidiospores surface to be nearly smooth. However, in 1992, Schild conducted further studies on the type specimens and observed basidiospores using

electron microscopy. It was discovered that the basidiospores of the type specimen of *R. obtusissima* are not smooth but have verrucose ornamentation. Consequently, Schild designated those species with truly smooth basidiospores as a new species, named *R. schildii*.

24. *Ramaria barenthalensis* Franchi & M. Marchetti, Riv. Micol. 61: 199 (2019). Fig. 16 a–b and Fig. 54

Description: *Basidiomata* 14 × 13 cm, medium sized, usually obtriangular to broadly fusiform in outline. *Stipe* 2 × 3 cm, single to falsely fasciculate, tapering gradually downward, smooth, without abortive branches, off-white where stipe protected below, cream to pale brown above, weakly

brunnescent, sometimes with pale brown to dark brown spots; flesh off-white, mottled hydrophanous, not gelatinous or slippery. *Major branches* 2–4, stout, terete, ascending, cream to yellow when young, mellowing to salmon or cream-ochre in age; flesh white, solid, not hydrophanous. *Branches* in 2–5 ranks, stout, ascending, concolorous with upper major branches below; internodes elongating through development, diminishing gradually at maturity; axils broad rounded throughout (both U-shaped and V-shaped). *Apices* dichotomous, stout, stiffly digitate, short and crowded, yellow to dark ochraceous, sometimes dark brown. Odor negligible or faintly fragrant; taste negligible or fabaceous.

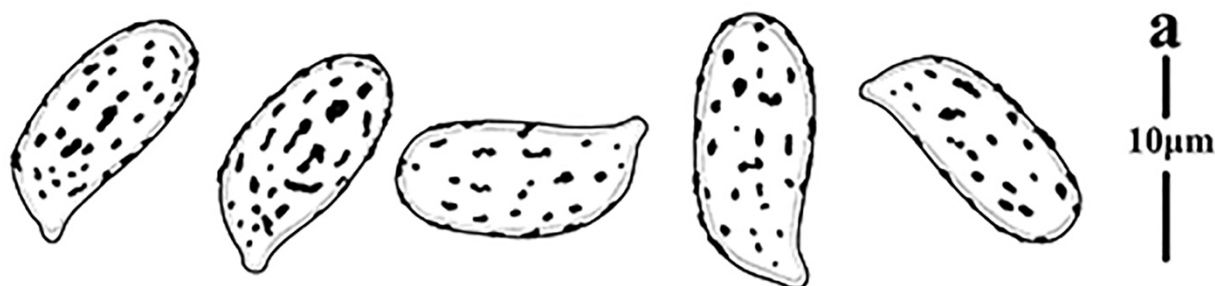


Fig. 54 Basidiospore features of *R. barenthalensis* (MHHNU 10091). Scale bar: a = 10 µm.

Basidiospores [30/2/2] (10.9–)11.2–13.6 × 4.4–5.5(–5.7) µm, $L_m = 12.23$ µm, $l_m = 4.93$ µm, $Q = (2.17\text{--})2.21\text{--}2.79(–2.92)$, $Q_m = 2.48 \pm 0.19$, sub-cylindrical, slightly roughened in profile; hilar appendix prominent, ornamentation of small warts and short ridges randomly placed. *Basidia* 50–85 × 7–14 µm, elongate-clavate, clamped at base; sterigmata 4, long, stout, slightly curved. *Subhymenium* rudimentary. *Hymenium* thickening. *Tramal hyphae* of *stipe* 5–16 µm wide, hyaline, clamped common, thick-walled (wall up to 1 µm thick), interwoven, not agglutinated or adherent; ampulliform clamps up to 18 µm broad, asymmetrical, not unusually thick-walled, with coarse ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae* of *upper branches* 4–18 µm wide, inflated especially in medullary regions, hyaline, conspicuously clamped, thick-walled (wall up to 1 µm thick), loosely parallel; ampulliform inflations rare, gloeoplerous hyphae not observed.

Ecology: In the forests with Fagaceae, *Picea*, *Quercus semecarpifolia*, or in other mixed forests.

Distribution: Known from southwest, central, and northeast China and at high altitude location (Yunnan, Sichuan, Xizang, Hubei, Jinlin).

Additional materials examined: CHINA, YUNNAN PROVINCE: Deqin County, Baima Snow Mountain Nature Reserve, altitude 3750 m, 17 August 2018, P. Zhang 3446 (MHHNU 9946); Qujing City, Qilin District, near Longyuan Zhumushan Wind Farm, altitude 2250 m, 19 August 2022, P. Zhang 4719 (MHHNU 11219). SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 6 September 2021, P. Zhang 4310 (MHHNU 10810), P. Zhang 4319 (MHHNU 10819); same location, 5 September 2021, P. Zhang 4268 (MHHNU 10768); same location, in the *Abies* forest, altitude 3500 m, 2 September 2021, P. Zhang 3586 (MHHNU 10086), P. Zhang 3591 (MHHNU 10091); same city, Gongga Township, in a mixed forest, altitude 3700 m, 24 August 2017, P. Zhang 2757 (MHHNU 9257), P. Zhang 2754 (MHHNU 9254); same city,

Mugecuo, in broad-leaved forest with Fagaceae, altitude 3500 m, 1 August 2012, Ping Zhang 1208 (MHHNU 7708). XIZNAG AUTONOMOUS REGION: Qamdo City, Changdu County, Ranwu Lake, in *Picea* forest, altitude 3,900 meters, 22 August 2018, P. Zhang 3479 (MHHNU 9979). HUBEI PROVINCE: Enshi, Hefeng County, Xiaping Township, Aimin Village, altitude 1100 m, 23 September 2019, Zuo H. Chen 31718 (MHHNU 31718). JILIN PROVINCE: Tonghua County, Baijifeng National Forest Park, in broadleaf forest, altitude 800 m, 6 August 2022, P. Zhang 4698 (MHHNU 11198); Jilin City, Jiaohe City, Shasong Mountain, Kangdalazi, altitude 1000 m, 9 August 2017, P. Zhang 2810 (MHHNU 9310). Liaodong Peninsula, in broad-leaved forest, 30 August 2018, P. Zhang 3609 (MHHNU 10109).

25. *Ramaria flavolongispora* P. Zhang & J. Zhong, *sp. nov.* Fig. 16 c–d and Fig. 55

Mycobank: MB 853370

Etymology: *flavolongispora* = *flava* + *longa* + *spora*, referring to the species having yellow-colored basidiomata and long basidiospores.

Diagnosis: Salmon-colored basidiomata, massive stipe, long basidiospores, crowded apices.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Nanhua County, Dazhongshan Forestry Farm, in a forest dominated by Fagaceae, altitude 2400 m, 11 October 2021, Jian W. Liu 2607 (Holotype, MHHNU 11653, GenBank Acc. No.: ITS = PP467278).

Description: *Basidiomata* 11 cm high and 10 cm broad, medium sized, usually obovate to obpyriform in outline. *Stipe* 4 × 5 cm, single to falsely fasciculate, stout, tapering gradually downward, longitudinally rugose, often with abortive branchlets, off-white (1A1) to cream (4A3), weakly brunnescent when injury; flesh solid, off-white (1A1), brittle. *Major branches* 2–4, stout, terete, ascending, milk white (1A2) to cream (4A3); flesh off-white (1A1), solid, not hydrophanous.

Branches in 2–5 ranks, ascending, milk white (1A2) to cream (4A3), weakly brunnescent; internodes all short when young, elongating below through development, diminishing gradually at maturity; axils narrowly rounded throughout, usually V-shaped. *Apices* double-dichotomous, crowded, narrowly rounded, digitate at maturity, concolorous with branches. Odor negligible or faintly fragrant; taste negligible or fabaceous.

Basidiospores [61/1/1] (11.1–)11.4–14.2(–15.4) × (3.1–)3.4–4.7(–4.9) μm , $L_m = 12.60 \mu\text{m}$, $l_m = 4.05 \mu\text{m}$, $Q = (2.50\text{--})2.63\text{--}3.79(4.11)$, $Q_m = 3.15 \pm 0.35$, cylindrical, roughened in profile, strongly cyanophilous; hilar appendix prominent,

ornamentation of warts and short ridges randomly placed. *Basidia* 48–70 × 5–12 μm , elongate-clavate, clamped at base; sterigmata 4, stout and long. *Subhymenium* rudimentary. *Hymenium* thickening. *Tramal hyphae* of *stipe* 5–13 μm wide, hyaline, conspicuously clamped, tightly interwoven, not agglutinated or adherent; ampulliform clamps up to 20 μm broad, with extensive, coarse, stalactitiform ornamentation; gloeoplerous hyphae rare. *Tramal hyphae* of *upper branches* 5–13 μm wide, inflated especially in medullary regions, hyaline, conspicuously clamped, tightly interwoven, ampulliform clamps up to 19 μm broad, gloeoplerous hyphae occasional.

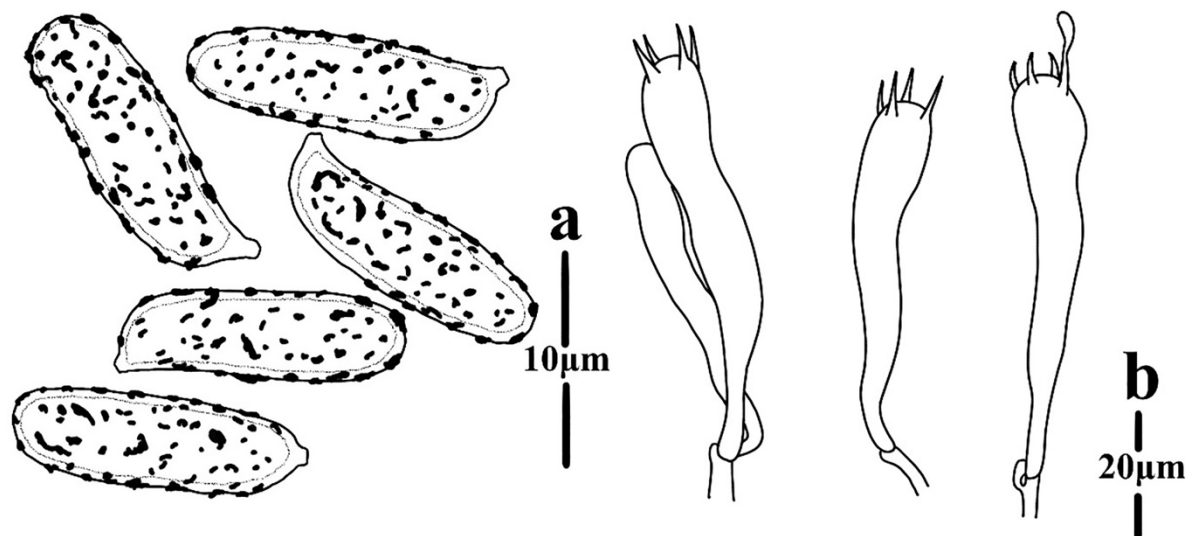


Fig. 55 Microscopic features of *R. flavolongispora* (MHHNU 11653). a basidiospores; b basidia. Scale bars: a =10 μm , b =20 μm .

Ecology: Solitary or gregarious on soil in broad-leaved forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional material examined: CHINA, YUNNAN PROVINCE: Wenshan, Malipo County, Mengdong Yao Township, Ailao Mountain range, in broad-leaved forest, altitude 1250 m, 29 July 2017, G. Wu 2273 (HKAS123587).

Commentary: *Ramaria flavolongispora* is closely related to *R. magnipes* and *R. rasilispora*. However, *R. flavolongispora* possesses the largest basidiospores among the three species (*R. magnipes* and *R. rasilispora* having basidiospores measuring 11.8 × 3.7 μm and 9.5 × 3.4 μm respectively). Additionally, the apices and branches of *R. flavolongispora* share the same color, whereas the apices of the other species are more or less brown in color.

26. *Ramaria hepatica* P. Zhang & G.W. Li, **sp. nov.** Fig. 16 e–f and Fig. 56

MycoBank: MB 853367

Etymology: “*hepatica*” refers to the species turning brown when injured or damaged.

Diagnosis: Basidiomata are cauliflower-like in appearance, start pale yellow when young and turns red brown as it matures, stipe is massive and turns dark brown with a yellowish tinge when bruised, basidiospores are cylindrical.

Type: CHINA, HUNAN PROVINCE: Zhangjiajie City, Yongding District, Tianmenshan National Forest Park, in a broadleaf forest, altitude 800 m, 9 September 2021, P. P.

Zhang 4416 (Holotype, MHHNU 10916, GenBank Acc. No.: ITS = PP467277, nrLSU = PP493583, *tef1-α* = PP482597).

Description: *Basidiomata* 8–10 cm high and 5–9 cm broad, small to medium sized, usually obovate to obpyriform in outline. *Stipe* 3–4 × 2–3 cm, single to falsely fasciculate, rounded at base, smooth upward, often with abortive branchlets, off-white (1A1) to pale yellow (2A3) when young, grayish orange (6B5) in age, slowly brunnescent when injury. *Flesh* solid, off-white (1A1), slowly brunnescent on handling, brittle, not gelatinous or slippery. *Major branches* 4–8, stout, terete, ascending, pale yellow (2A3) to salmon (6A4) when young or *flesh* (6B3), easily mellowing to light brown (6D6) to brown (6E8) through development; *flesh* off-white (1A1), solid, not hydrophanous. *Branches* in 3–6 ranks, ascending, concolorous with upper major branches, internodes all short when young, elongating below through development, diminishing gradually at maturity; axils narrowly rounded throughout, usually (both U-shaped and V-shaped). *Apices* are double-dichotomous, crowded when young, acute, short, digitate at maturity, finally concolorous with branches, light brown (6D6) to brown (6E8) in age. Odor negligible or faintly fragrant; taste negligible or fabaceous.

Basidiospores [40/2/2] 11.0–13.0 × 4.0–5.0 μm , $L_m = 12.00 \mu\text{m}$, $l_m = 4.68 \mu\text{m}$, $Q = (2.17\text{--})2.20\text{--}3.00(3.25)$, $Q_m = 2.59 \pm 0.29$, ellipsoid to cylindrical, roughened in profile, strongly cyanophilous; hilar appendix prominent, yellow to brown, 6–8 μm long, ornamentation of warts and short ridges randomly placed. *Basidia* 42–65 × 9–12 μm , elongate-clavate, clamped

at base; sterigmata 4, stout and long. *Subhymenium* rudimentary. *Hymenium* thickening. *Tramal hyphae* of stipe 5–14 μm wide, hyaline, conspicuously clamped, tightly interwoven, not agglutinated or adherent; ampulliform clamps up to 16 μm broad, with extensive, coarse, stalactitiform ornamentation; gloeoplerous hyphae rare. *Tramal hyphae* of upper branches 5–16 μm wide, inflated especially in medium sized regions, hyaline, conspicuously clamped, tightly interwoven, ampulliform clamps up to 16 μm broad, gloeoplerous hyphae occasional.

Ecology: Solitary or gregarious on soil in broad-leaved forests; basidiomata occurs in summer and autumn.

Distribution: Known from central China (Hunan).

Additional materials examined: CHINA, HUNAN PROVINCE: Zhangjiajie City, Yongding District, Tianmenshan National Forest Park, in a broadleaf forest, altitude 800 m, 9 September 2021, P. Zhang 4415 (MHHNU 10915); Changde

City, Shimen County, Hupingshan Town, Hupingshan National Nature Reserve, in a broad-leaved forest, altitude 1000 m, 3 October 2010, Zuo H. Chen 30754 (MHHNU 30754).

Commentary: *Ramaria brunneicontusa* R. H. Petersen, *R. pseudoflava* Franchi & M. Marchetti, and *R. flava* greatly resemble species in *Ramaria*, characterized by yellow basidiomata and clamps. *Ramaria hepatica* and *R. flava* share a similar basidiospores size, but the former exhibits a pale yellow basidiomata when young, turning red brown with age, whereas the latter's basidiomata remains consistently yellow. *Ramaria pseudoflava* has smaller basidiospores ($10.7 \times 4.0 \mu\text{m}$; Franchi & Marchetti 2021) and its basidiomata are gold yellow at maturity without changing color. *Ramaria hepatica* and *R. brunneicontusa* both change color when bruised or handled, but *R. brunneicontusa* has longer basidiospores measuring ($13.0\text{--}16.6 \times 4.7\text{--}6.1 \mu\text{m}$; Petersen 1989).

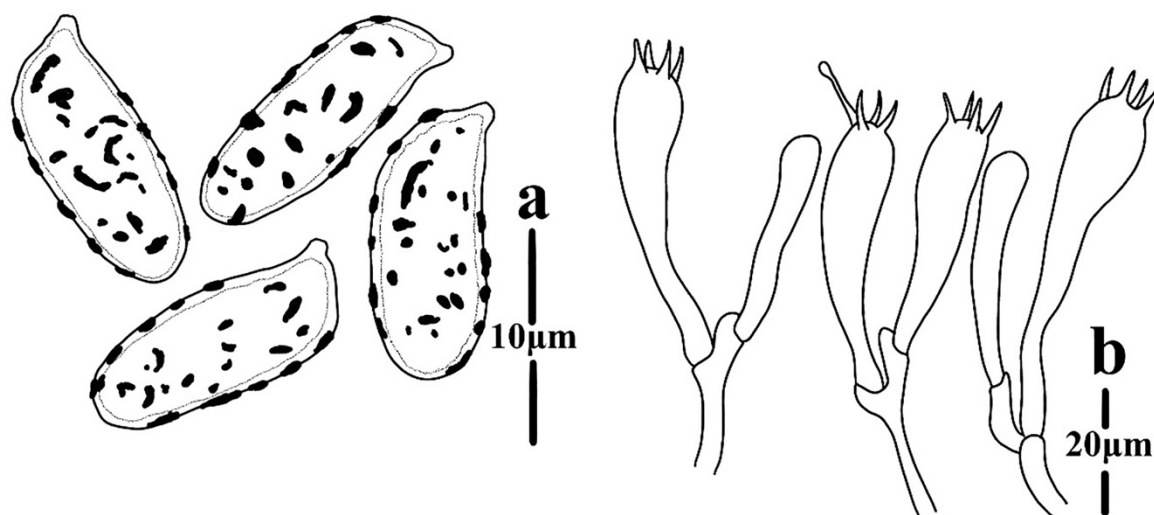


Fig. 56 Microscopic features of *R. hepatica* (MHHNU 10916). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

27. *Ramaria laevibrunnea* P. Zhang & Zai W. Ge, **sp. nov.** Fig. 16 g–h and Fig. 57

Mycobank: MB 853371

Etymology: *laevibrunnea* = “*laevi-*” + “*brunnea*”, referring to the brown-colored basidiomata of the species and its nearly smooth basidiospores.

Diagnosis: Yellow to salmon basidiomata; clamped basidia and hyphae; basidiospores are nearly smooth; turns dark brown when bruised or handled.

Type: CHINA, YUNNAN PROVINCE: Dali, Yongping County, Beidou Township, Yuntai Mountain, in a mixed forest by *Keteleeria* and *Pinus*, altitude 2400 m 22 August 2017, Zai W. Ge 4028 (Holotype, HKAS 105942 GenBank Acc. No.: ITS = PP467280, nrLSU = PP493584).

Description: *Basidiomata* 9 cm high and 8 cm broad, medium sized, usually subcircular to commashaped in outline. *Stipe* 3 $\times$ 2 cm, falsely fasciculate, nearly smooth, tapering gradually downward, without abortive branchlets at maturity; off-white (1A1) to pastel yellow (2A4) downward, ivory (4B3) to cinnamon brown (6D6) upward, weakly brunnescent when hurt or handle; flesh off-white (1A1), solid, pale yellow (2A3), not gelatinous, or slippery. *Major branches* several, ascending, terete, concolorous with stipe downward,

concolorous with branches upward, weakly brunnescent when hurt or handle. *Branches* in 2–4 ranks, terete, cream (4A3) to sunshine yellow (2A5) colored, maturity to cinnamon brown (6D6); flesh paler than hymenium, soft; internodes all short when young, elongating from below, diminishing gradually upward at maturity; axils broadly rounded throughout (U shaped). *Apices* rounded and pale yellow (2A3) when young, acute and cinnamon brown (6D6) in age; Odor faintly penetrating; taste negligible.

Basidiospores [31/1/1] ($11.8\text{--}12.3\text{--}14.9\text{--}(16.9) \times (4.1\text{--})4.2\text{--}5.3\text{--}(5.8) \mu\text{m}$, $L_m = 13.70 \mu\text{m}$, $l_m = 4.82 \mu\text{m}$, $Q = (2.19\text{--})2.46\text{--}3.36\text{--}(3.54)$, $Q_m = 2.86 \pm 0.28$, cylindrical to ellipsoid, smooth or extremely obscurely undulate in profile; wall up to 0.2 μm thick; hilar appendix small, not prominent, truncate; ornamentation none. **Basidia** 30–42 $\times$ 6–12 μm , clavate, short, clamped; sterigmata (2–) 4, short, spindly, straight. *Subhymenium* rudimentary, pseudoparenchymatous. *Hymenium* thickening. *Tram-al hyphae* of stipe 4–12 μm wide, usually inflated, hyaline, thick walled (wall up to 1.5 μm thick locally), tightly interwoven, not agglutinated or adherent; ampulliform clamps up to 16 μm broad, thick-walled (wall up to 1.5 μm thick), with coarse ornamentation; gloeoplerous hyphae not observed; *Tramal hyphae* of upper branches up

to 3–10 µm wide, hyaline, thin-to thick-walled (wall up to 1 µm thick locally), clamped, secondarily septum, interwoven, not agglutinated or adherent; ampulliform clamps up to 14 µm broad, thick-walled (wall up to 1 µm thick), coarse ornamentation; gloeoplerous hyphae not observed.

Ecology: Found in *Picea* and broad-leaved mixed forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Dali, Dali City, Xianyangfeng, in a mixed forest, altitude 2800 m, 12 August 2018, P. Zhang 3375 (MHHNU

9875); Chuxiong, Nanhua County, Dazhongshan Forestry Farm, in mixed broadleaf-coniferous forest, altitude 2218 m, 9 August 2017, Jian W. Liu 781 (MHHNU 11639).

Commentary: *Ramaria laevibrunnea* is distinguished as the first smooth-spores *Ramaria* with young salmon coloration that darkens to brown with age. The species closely resemble *R. laeviformosoides*, both sharing nearly smooth basidiospores, clamps, and similar salmon basidiomata. However, *R. laevibrunnea* noticeably turns dark brown, while *R. laeviformosoides* only exhibits slight browning.

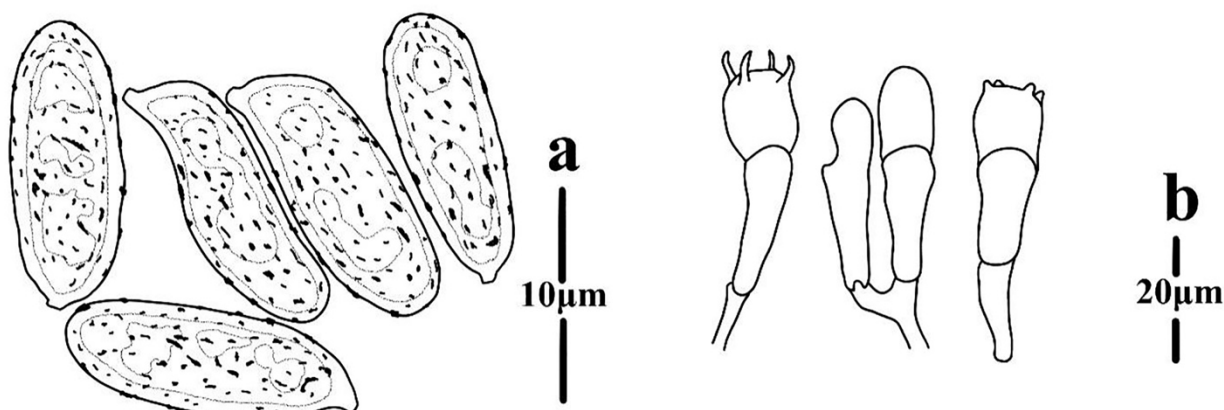


Fig. 57 Microscopic features of *R. laevibrunnea* (MHHNU 11639). a basidiospores; b basidia. Scale bars: a =10 µm, b =20 µm.

28. *Ramaria pallidobrunnea* P. Zhang & J. Zhong, *sp. nov.* Fig. 16 i–j and Fig. 58

Mycobank: MB 853369

Etymology: *pallidobrunnea* = *pallida* + *brunnea*, refers to the basidiomata of the species being light brown colored.

Diagnosis: Basidiomata are yellow, easily and extensively turning brunnescent; basidia are clamped and long; basidiospores are smooth, virtually unornamented.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding County, Mugecuo, in forest dominated by *Abies* and Pinaceae, altitude 3800 m, 21 August 2017, P. Zhang 2713 (Holotype, MHHNU 9213, GenBank Acc. No.: ITS = PP467270, nrLSU = PP493576, *tef1-α* = PP480439).

Description: Basidiomata 20 cm high and 13 cm broad, massive, circular to broadly obovate in outline. Stipe 4 × 4 cm, small to large, rounded to lapping sharply to acute or rooting base, smooth, with a few abortive stumps high on stipe or low on lower branches, off-white (1A1) to yellowish white (2A2), very easily brunnescent; flesh off-white (1A1), slowly brunnescent when cut, solid, mottled-hydrophanous, but not gelatinous or slippery, often with a yellowish band suffused near base, dry flesh firm but easily penetrated. Major branches 2–4, massive, hardly terete, ascending, pale yellow (2A3) to flesh (6B3) when young, easily mellowing to pastel yellow (2A4) through development; flesh off-white (1A1), solid, not hydrophanous. Branches in 3–6 ranks, stout, ascending, concolorous with upper major branches, internodes all short when young, elongating below through development, diminishing gradually at maturity; axils rounded throughout. Apices are sometimes finely divided, acute, double-dichotomous, usually gross, molar-like, short-digitate at maturity, pastel yellow (2A4) to chrome yellow (3A8), off-white (1A1) where protected. Odor negligible or faintly fragrant; taste negligible or fabaceous.

Basidiospores [50/2/2](12.0–)13.0–15.2(–15.5) × 4.2–5.6(–5.8) µm, $L_m = 14.05$ µm, $l_m = 4.81$ µm, $Q = (2.60)–2.67–3.33$, $Q_m = 2.92 \pm 0.21$, boletoid to cylindrical, flattened adaxially or with a suprahilar swelling, smooth in profile; wall up to 0.2 µm thick, hilar appendix not prominent, ornamentation usually none, occasionally a suggestion of ill-defined, moderately cyanophilous markings of delicate ridges and small patches, in more or less longitudinal orientation. **Basidia** 95–115 × 10–11 µm, elongate-clavate, clamped at base; sterigmata 4, long, slender, straight. **Subhymenium** rudimentary. **Hymenium** thickening. **Tramal hyphae of stipe** 5–16 µm wide, hyaline, clamped, thick-walled (wall up to 1.5 µm thick), interwoven, not agglutinated or adherent; ampulliform clamps up to 18 µm broad, asymmetrical, not unusually thick-walled, with extensive, coarse, stalactitiform ornamentation; gloeoplerous hyphae rare, 3–5 µm, yellow-refractive. **Tramal hyphae of upper branches** 4–28 µm wide, inflated especially in medullary regions, hyaline, conspicuously clamped, thin to thick-walled (wall up to 1 µm thick locally), with common false clamps, loosely parallel, ampulliform inflations not observed, gloeoplerous hyphae occasional, 2.5–5 µm diam, yellow, refractive, with abrupt swellings.

Ecology: Found on soil in a broad-leaved and coniferous mixed forest; basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La, Bitahai, in a subalpine forest, altitude 3800 m, 26 August 2020, Zuo H. Chen 32322 (MHHNU 32322); same city, Zhongdian County, Zhongdian Snow Mountain, 24 August 2000, Zhu L. Yang 3015 (HKAS 36561). SICHUAN PROVINCE: Ganzi, Xiangcheng County, Reda Township, altitude 3400 m, Zai W. Ge 123 (HKAS 45890). XIZANG AUTONOMOUS REGION: Linzhi City, Milin County, Zhaxiraodeng Village, in *Picea* forest, altitude 3040 m, 24

August 2018, Ping Zhang 3485 (MHHNU 9985); Leiwuqi, in a subalpine forest, altitude 3900 m, 24 August 2004, Zhu L. Yang 4355 (HKAS 45734); Jiangda County, altitude 3800 m, Zai W. Ge 229 (HKAS 46009).

Commentary: A taxonomic complex of nearly smooth-spored taxa within *Ramaria* includes North American species such as *R. obtusissima* var. *obtusissima* (Corner 1950) and *R. highlandensis* (Petersen 1989), which occur in summer, along with one western North American taxon and its varieties (*R. magnipes* var. *magnipes*, Marr & Stuntz 1973; and var. *Albidior*, Petersen & Scates 1988), known as vernal fruiters.

Additionally, there are two European taxa (*R. obtusissima* var. *Scandinavica*, Petersen 1989; and an undescribed taxon), and one North American taxon exhibiting weakly amyloid stipe flesh but otherwise showing macro-chemical inertness.

The common features among *R. pallidobrunnea* include basidiomata displaying yellow or ochre-yellow tones, basidiospores with subtle roughness, and slight browning upon minor injury. Due to their morphological similarities, accurate differentiation of these species requires integrating molecular biological evidence and geographical factors.

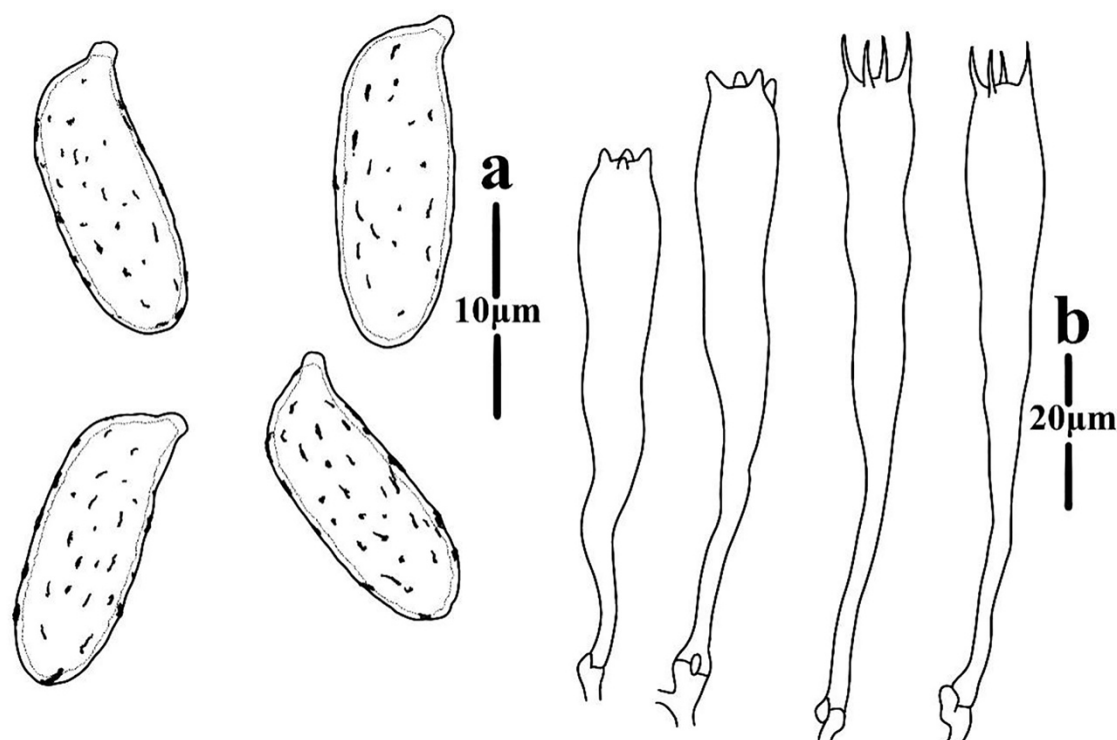


Fig. 58 Microscopic features of *R. pallidobrunnea* (MHHNU 9213). a basidiospores; b basidia. Scale bars: a =10 µm, b =20 µm.

29. *Ramaria verrucula* P. Zhang & J. Zhong, **sp. nov.** Fig. 16 k–l and Fig. 59

Mycobank: MB 853360

Etymology: “*verrucula*” refers to the finely warty basidiospores of this species.

Diagnosis: Basidiomata are light yellow in color, with apices and stipe brunnescent reluctantly; stipe is massive; basidia are slightly short and conspicuously clamped; basidiospores’ ornamentation is usually fine.

Type: CHINA, HUBEI PROVINCE: Enshi, Hefeng County, Wuyang Township, Hewan Village, altitude 1000 m, 24 September 2019, Zuo H. Chen 31735 (Holotype, MHHNU 31735, GenBank Acc. No.: ITS = PP467272, nrLSU = PP493578, *tef1-α* = PP480441).

Description: Basidiomata 10 cm high and 7 cm broad, small to medium sized, usually obovate to obpyriform in outline. Stipe 3 × 6 cm, single to falsely fasciculate, large to stout, tapering gradually to the acute, pruinose at base, sometimes with very few abortive branchlets, off-white (1A1) to pale yellow (2A3); flesh solid, off-white (1A1), not gelatinous or slippery, reluctantly brunnescent on handling, not gelatinous or slippery. Major branches 2–4, massive, terete, ascending, pale yellow (2A3) when young or flesh (6B3), easily mellowing to grayish orange (6B5) through development;

flesh off-white (1A1), solid, not hydrophanous. Branches in 3–6 ranks, ascending, concolorous with upper major branches, internodes all short when young, elongating below through development, diminishing gradually at maturity; axils narrowly rounded throughout. Apices cuspidate or double-dichotomous, crowded when young, sunshine yellow (2A5) to grayish orange (6B5), brownish in age. Odor negligible or faintly fragrant; taste negligible or fabaceous.

Basidiospores [58/2/2] (10.9–)11.8–13.5(–13.9) × (3.6–)3.9–5.3(–5.6) µm, $L_m = 12.11$ µm, $l_m = 4.64$ µm, $Q = (2.19–)2.28–3.07(–3.37)$, $Q_m = 2.64 \pm 0.26$, cylindrical; hilar appendix prominent, ornamentation usually fine. **Basidia** 35–70 × 5–11 µm, elongate-clavate, clamped at base; sterigmata 4, stout and long. **Subhymenium** rudimentary. **Hymenium** thickening. **Tramal hyphae of stipe** 5–14 µm wide, hyaline, conspicuously clamped, thick-walled (wall up to 1 µm thick), interwoven, not agglutinated or adherent; ampulliform clamps up to 18 µm broad, asymmetrical, with extensive, coarse, stalactiform ornamentation; gloeoplerous hyphae rare. **Tramal hyphae of upper branches** 5–16 µm wide, inflated especially in medium sized regions, hyaline, conspicuously clamped, thin to thick-walled (wall up to 1 µm thick locally), loosely parallel, ampulliform clamps up to 16 µm broad, gloeoplerous hyphae occasional.

Ecology: Found in a broad-leaved and coniferous mixed forest; basidiomata occurs in autumn.

Distribution: Known from central China (Hubei).

Commentary: In the genus *Ramaria*, there are several species characterized by minutely warted basidiospores and yellow basidiomata. The species most closely related to this

group is *R. hepatica*, which shares similarities in basidiospores size ($12.00 \times 4.68 \mu\text{m}$, as measured in this study) and ornamentation. However, the basidiomata of *R. hepatica* are cauliflower-like in appearance, initially pale yellow when young, and turning reddish brown as they mature.

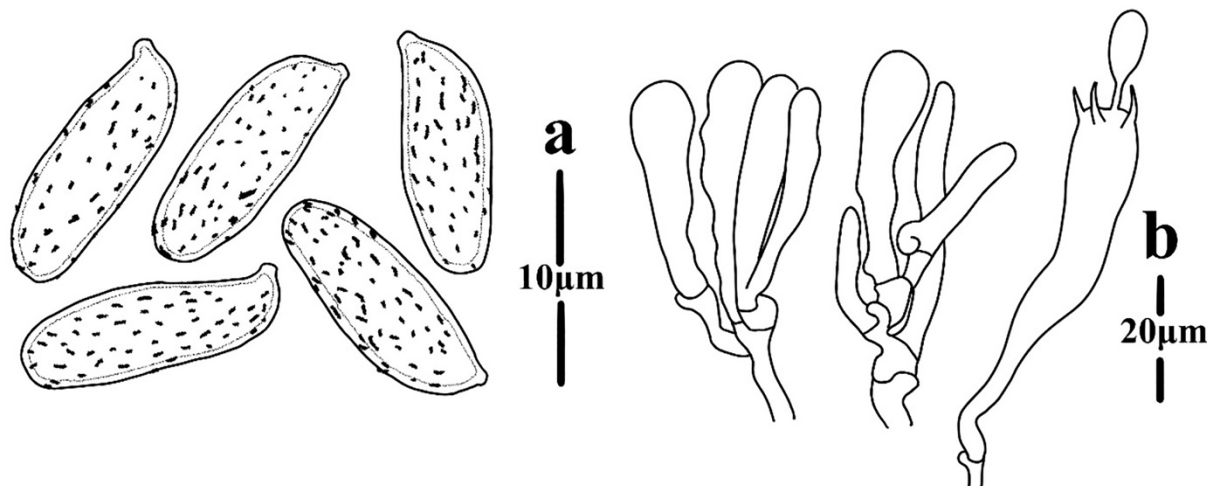


Fig. 59 Microscopic features of *R. verrucula* (MHHNU 31735). a basidiospores; b basidia. Scale bars: a = $10 \mu\text{m}$, b = $20 \mu\text{m}$.

Ramaria* ser. *Flavescentoides P. Zhang & J. Zhong, ser. nov.

Mycobank: MB 852775

Etymology: Species features are very similar to *R. flavesces*.

Type species: *R. flavescentoides* Hanif & Khalid, Mycotaxon 134(2): 402 (2019).

Diagnosis: Basidiomata are pale yellow to pale orange in color; apices are broadly rounded and concolorous with branches; basidiospores are long and conspicuously roughened in profile; hyphae and basidia base have clamps.

Commentary: This series includes four species collected in China, along with additional species such as *R. rubricarnata* Marr & D.E. Stuntz, *R. thiersii* R.H. Petersen & Scates, *R. flavesces* (Schaeff.) R.H. Petersen.

30. ***Ramaria brunneipes*** R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 374, 1989. Fig. 17 a and Fig. 60

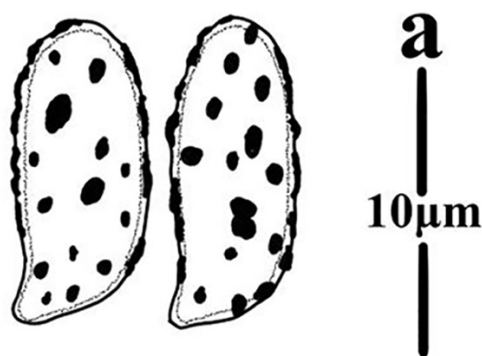


Fig. 60 Basidiospore features of *R. brunneipes* (MHHNU 6623). Scale bar: a = $10 \mu\text{m}$.

Description: Basidiomata 12 cm high and 7 cm broad, medium sized to large, usually single to fasciculate habit.

Stipe 3 × 4 cm, single to compound, fleshy, large to robust, tapering gradually downward, rounded at base; off-white at base, off-white to butter yellow upward; not changing color or slightly changing color to brownish yellow to brown on bruising; surface smooth; occasionally with abortive branches; context of stipe off-white, fleshy, drying light in weight, easily penetrated, but not friable. Branches in 3–6 ranks, major branches and branches above commonly polychotomous; inner branches and young branches pale yellow to pale orange when young, cream to butter yellow at age; axils narrowly rounded, mostly V-shaped; internodes all short, lower internodes up to 1.5 cm; branches slender and crowded, commonly 2–5 mm, seldom over 1 cm diam, terete, subparallel; context of main branches and upper branches fleshy-gelatinous, off-white. Apices cuspidate, short and crowded, 1–3 mm long, polychotomous, concolorous with branches. Odor and taste faintly fabaceous.

Basidiospores $[60/2/2]$ $(9.2\text{--}9.6\text{--}12.7\text{--}(13.0) \times (3.3\text{--}3.9\text{--}6.0 \mu\text{m}, L_m = 11.06 \mu\text{m}, l_m = 4.71 \mu\text{m}, Q = (1.67\text{--}2.00\text{--}2.78\text{--}3.34), Q_m = 2.38 \pm 0.29$, subcylindrical; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. **Basidia** $50\text{--}65 \times 9\text{--}13 \mu\text{m}$, clavate, with basal clamps; sterigmata 4, 4–6 μm long, incurved or straight, slightly divergent. **Hymenium** unthickening, 55–70 μm . **Subhymenium** extensive, 15–30 μm thick, hyphae, interwoven, 3–6 μm diam, thin-walled, with clamps. **Contextual hyphae:** Tramal hyphae of stipe 3–15 μm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 19 μm , with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 18 μm , with smooth and thin wall; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae common, 7–10 μm diam.

Ecology: Found in broad-leaved, coniferous, or mixed forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, bought from mushroom market, 9 September 1986, Petersen 47303 (isotype, HKAS 20048); Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 3 August 2001, P. Zhang 123 (MHHNU 6623).

Commentary: Several yellowish basidiomata species share similarities with *R. brunneipes*, including *R. flavescens*, *R. flavescens* and its variants, *R. formosa* and its variants, *R. pseudoflava*, and *R. barenthalensis*. However, these species differ in various aspects such as basidiospores size, color, and apices morphology. A distinguishing feature for *R. brunneipes* is their stout stipes and extremely slender, crowded and subparallel branches. Notably, most of the other yellow species have primarily been reported in North America and Europe, whereas *R. brunneipes* is confirmed through our two-gene molecular phylogenetic analysis to be distinct from other yellow *Ramaria* species. The species most closely related to *R. obtusa* is *R. flavescens*. These two species share similar coloration, basidiospores sizes, and exhibit comparable features of a stout stipe and crowded branches. However, a key distinction lies in the branching pattern: *R. flavescens* has shorter internodes, and the branches are more dispersed, whereas *R. brunneipes* has longer internodes and branches that are sub-parallel.

31. *Ramaria compressipes* P. Zhang & J. Zhong, *sp. nov.* Fig. 17 b and Fig. 61

Mycobank: MB 853293

Etymology: “*compressipes*” denotes the characteristic of the species having flattened stipes.

Diagnosis: Basidiomata are medium sized to large, cauliflower-like, cream to salmon colored; branches and apices are crowded, with apices concolorous with branches or turning brownish in maturity; slightly turn brownish when injured; basidiospores are long and narrowly, roughened in profile; hyphae and basidia base have clamps.

Type: CHINA, YUNNAN PROVINCE: Lijiang City, Yulong County, Baisha Township, Lijiang Alpine Botanical Garden,

altitude 3569 m, 29 September 2019, Jian W. Liu 1809 (Holotype, MHHNU 11644, GenBank Acc. No.: ITS = PP467208).

Description: *Basidiomata* 8 cm high and 9 cm broad, single to fasciculate habit, medium sized, cauliflower-like in outline. *Stipe* 5 × 4 cm, single to compound, fleshy, large to robust, tapering gradually downward to narrowly rounded at base; off-white (1A1) at base, cream (4A3) to butter yellow (4A5) upward; slightly changing color to brownish yellow (5B3) on bruising; surface smooth; without abortive branches; context of stipe off-white (1A1), fibrous to spongy, drying light in weight, easily penetrated. *Branches* in 3–5 ranks, major branches and branches above commonly polychotomous; young branches pale yellow (2A43) to butter yellow (4A5), cream (4A3) to grayish orange (6B5) at age; axils narrowly rounded, mostly V-shaped; internodes all short, lower internodes up to 1 cm; branches slender and crowded, commonly 1–3 mm, terete, ascending; context of main branches and upper branches fleshy to gelatinous, pale yellow (2A3). *Apices* short and crowded, digitate to molar-like when young, coarsely digitate by maturity, 1–2 mm long, polychotomous, axils near apices 2–8 times. Odor and taste faintly fabaceous.

Basidiospores [33/1/1] (9.6–)10.2–13.0(–13.4) × (3.3–)3.8–4.9(–5.4) μm, $L_m = 11.34$ μm, $l_m = 4.25$ μm, $Q = (2.26–)2.39–3.09(–3.19)$, $Q_m = 2.68 \pm 0.23$, subcylindrical to narrowly ellipsoid; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 50–65 × 8–12 μm, clavate, with basal clamps; sterigmata 4, 3–6 μm long, incurved or straight, slightly divergent. *Hymenium* unthickening, 55–70 μm. *Subhymenium* extensive, 15–30 μm thick, hyphae, interwoven, 3–6 μm diam, thin-walled, with clamps. *Contextual hyphae:* Tramal hyphae of stipe 3–15 μm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 19 μm, with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 18 μm, with smooth and thin wall; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae common, 7–10 μm diam.

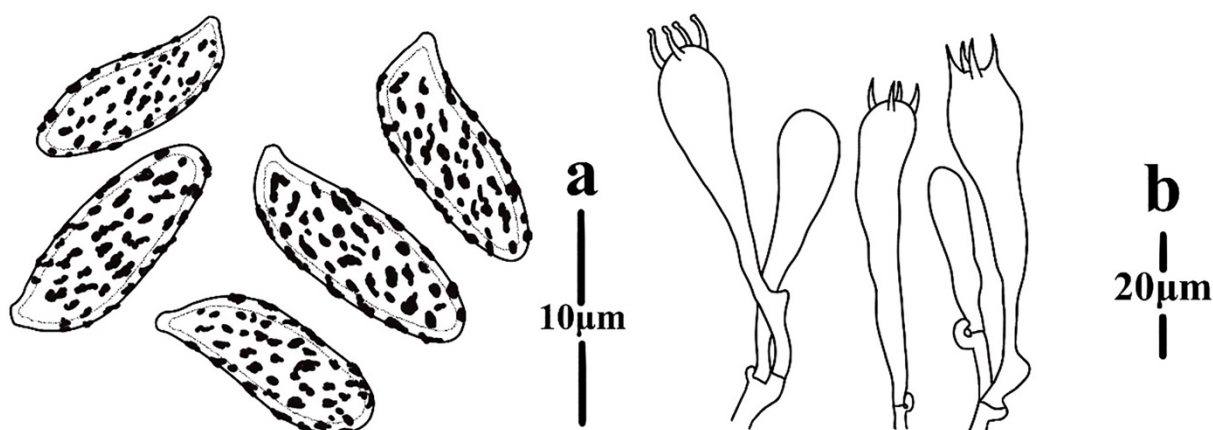


Fig. 61 Microscopic features of *R. compressipes* (MHHNU 11644). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Ecology: Found in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern (Yunnan).

Additional material examined: CHINA, YUNNAN PROVINCE: Deqin County, Feilaisi Forest Park, altitude 3400 m, 19 August 2018, P. Zhang 3417 (MHHNU 9917).

Commentary: *Ramaria compressipes* shares similarities with the *R. thiersii* R.H. Petersen & Scates in North American. Both exhibit cauliflower-like structures in basidiomata, obpyramidal and stout stipe, similar yellow to salmon-colored basidiomata, and are exclusively found in high-altitude regions (above 3000 meters) on gritty soil under the humus layer. The distinguishing feature lies in the smaller basidiospores of *R. compressipes*.

Furthermore, *Ramaria compressipes* exhibits similarities with *R. rubricarnata* Marr & D.E. Stuntz and its variants in the North American, displaying a similar botrytis-like morphology. The main differences lie in the latter's orange coloration with slightly smaller basidiospores. Notably, the hymenium of *R. rubricarnata* young specimens are beautiful rich maize yellow colored, and context is salmon colored, as opposed to the light orange to pinkish color in the lower branch's context.

Additionally, *R. compressipes* shares morphological similarities with *R. brunneipes*. However, *R. compressipes* is distinguished by its short, digitate to molar-like apices, whereas *R. brunneipes* has slender apices.

32. *Ramaria flavescentoides* Hanif & Khalid, Mycotaxon 134(2): 402 (2019). Fig. 17 c–d and Fig. 62

Description: Basidiomata 6–9 cm high and 3–5 cm broad, repeatedly branched, usually obovate to obconic in outline. Stipe 1–2 × 1–3 cm, compound to fasciculate in groups of 2–5, tapering gradually downward into a basal mycelial mat or white tomentum covering the stipe base; off-white to pale orange at base, pale yellow to pale orange upward; not changing color on bruising; surface smooth; without abortive branches; context of stipe off-white, solid, dried flesh firm but easily penetrated, gelatinous or slippery. Branches in 4–7 ranks, major branches 4–6, 1.5–2 cm diam, stout, more or less terete, ascending, pale yellow to pale orange below, upward paler; axils narrowly rounded, mostly U-shaped; internodes diminishing gradually at maturity, lower internodes up to 3 cm;

branches above commonly polychotomous, broader upward, commonly 5–20 mm diam, terete or flattened, crowded, ascending, slightly divergent; context of main branches and upper branches gelatinous, off-white to pale orange. Apices broadly rounded, short, 2–4 mm long, polychotomous, concolorous with branches or sometimes slightly changing color to brownish yellow on bruising. Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (10.2–)11.1–14.9(–15.6) × (4.0–)4.5–6.5(–7.0) µm, $L_m = 12.40$ µm, $l_m = 5.27$ µm, $Q = (1.82)–2.01–2.88(–3.27)$, $Q_m = 2.38 \pm 0.26$, oblong to ellipsoid; ornamented with low coarse warts and delicate meandering ridges covering significant areas of wall, strongly cyanophilous warts; hilar conspicuous, slightly curved at one end. **Basidia** 55–65 × 9–13 µm, clavate, with basal clamps; sterigmata 2–4, mostly 4, 5–8 µm long, incurved or straight, slightly divergent. **Hymenium** unthickening, 75–80 µm. **Subhymenium** rudimentary, 15–30 µm thick, hyphae, interwoven, 3–6 µm diam, thick-walled, with clamps. **Contextual hyphae:** Tramal hyphae of stipe 6–12 µm wide, hyaline, parallel, inflating slightly, terminal swollen hyphae wide to 15 µm, with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 15 µm, with smooth and thin wall; ampulliform hyphae occasional; with frequently clamps; gloeoplerous frequently, 7–10 µm diam.

Ecology: Found in a mixed forest with *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known from northeast China and southwest China (Xizang), Pakistan.

Additional materials examined: CHINA, XIZANG AUTONOMOUS REGION: Linzhi City, Milin County, Zhaxiraodeng Village, in *Picea* forest, altitude 3040 m, 24 August 2018, P. Zhang 3483 (MHHNU 9983), P. Zhang 3489 (MHHNU 9989); same city, 25 August 2018, P. Zhang 3496 (MHHNU 9996).



Fig. 62 Basidiospore features of *R. flavescentoides* (MHHNU 9996). Scale bar: a = 10 µm.

Commentary: The main features of *R. flavescentoides* include: 1) basidiomata medium sized, obovate to obconic basidiomata, pale yellow to pale orange colored; 2) apices broadly rounded, concolorous with branches or slightly changing color to brown when matured; 3) basidiospores long, slightly curved, conspicuously roughened in profile; 4) hyphae and basidia base with clamps.

R. flavescentoides resembles *R. flavescentoides* (Schaeff.) R.H. Petersen in shape, branching pattern, and basidiomata color, also sharing a similar basidiospores shape and ornamentation and the presence of basidial clamps. However, *R. flavescentoides* has smaller basidiomata and smaller basidiospores. Hanif & Khalid noted that it's have stellate

crystalline material in the hyphae of upper branches, which similar crystals have been reported by Zhang & al (Zhang et al. 2005) in the stipe and upper branches of *R. luteo-aeruginea* P. Zhang & Zhu L. Yang in subgen. *Echinoramaria* (*Phaeoclavulina*).

R. flavescentoides also resembles *R. rasilisporoides*, however, *R. rasilisporoides* differs from *R. flavescentoides* in its pale yellow basidiomata, amyloid stipe tissues, deeply rooting stipe with numerous abortive branchlets, and smaller basidiospores (Exeter et al. 2006).

R. flavescentoides and *R. mairei* Donk were the only two species of old subgen. *Laeticolora* previously reported from Pakistan (Hanif et al. 2019), the latter is distinguished by

larger (18 cm) basidiomata, 8 cm high stipe, numerous pallid or deep lemon to pale ochraceous and rather lax or crowded branches, and slightly longer (10–15 μm) oblong to ellipsoid roughened pale ochraceous basidiospores.

33. *Ramaria obtusa* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 23 (2024) Fig. 17 e–f and Fig. 63

Description: *Basidiomata* 12 cm high and 7 cm broad, medium sized to large, usually single to fasciculate habit. *Stipe* 3 $\times$ 4 cm, single to compound, fleshy, large to robust, tapering gradually downward, rounded at base; off-white at base, off-white to butter yellow upward; not changing color or slightly changing color to brownish yellow to brown on bruising; surface smooth; occasionally with abortive branches; context of stipe off-white, fleshy, drying light in weight, easily penetrated, but not friable. *Branches* in 3–6 ranks, major branches and branches above commonly polychotomous; inner branches and young branches pale yellow to pale orange when young, cream to butter yellow at age; axils narrowly rounded, mostly V-shaped; internodes all short, lower internodes up to 1.5 cm; branches slender and crowded, commonly 2–5 mm, seldom over 1 cm diam, terete, subparallel; context of main branches and upper branches fleshy-gelatinous, off-white. *Apices* cuspidate, short and crowded, 1–3 mm long, polychotomous, concolorous with branches. Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (9.2–)9.6–12.7(–13.0) $\times$ (3.3–)3.9–6.0 μm , $L_m = 11.06 \mu\text{m}$, $l_m = 4071 \mu\text{m}$, $Q = (1.67\text{--})2.00\text{--}2.78(3.34)$, $Q_m = 2.38 \pm 0.29$, subcylindrical; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 50–65 $\times$ 9–13 μm , clavate, with basal clamps; sterigmata 4, 4–6 μm long, incurved or straight, slightly divergent. *Hymenium* unthickening, 55–70 μm . *Subhymenium* extensive, 15–30 μm thick, hyphae, interwoven, 3–6 μm diam, thin-walled, with clamps. *Contextual hyphae*: Tramal hyphae of stipe 3–15 μm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 19 μm , with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 18 μm , with smooth and thin wall; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae common, 7–10 μm diam.

Ecology: Found in broad-leaved, coniferous, or mixed

forests. Basidiomata occurs in summer and autumn.

Distribution: Known from central, north and northeastern of China (Hunan, Jilin, Shanxi).

Additional materials examined: CHINA, HUNAN PROVINCE: Changde City, Shimen County, Hupingshan National Nature Reserve, Huier Bay, in broadleaf forest, altitude 1600 m, 10 September 2012, P. Zhang 1264 (MHHNU 7764). JILIN PROVINCE: Tonghua City, Baijifeng Forest Park, in mixed forests dominated by *Acer*, *Quercus* and *Pinus*, altitude 800 m, 28 Aug. 2020, P. Zhang 4043 (MHHNU 10553); 28 Aug. 2020, P. Zhang 4053 (MHHNU 10091).

Commentary: Several yellowish basidiomata species share similarities with *R. obtusa*, including *R. flavescentoides*, *R. flavescentoides* and its variants, *R. formosa* and its variants, *R. pseudoflava*, and *R. barenthalensis*. However, these species differ in various aspects such as basidiospores size, color, and apices morphology. A distinguishing feature for *R. obtusa* is its stout stipes and extremely slender, crowded and subparallel branches. Notably, most of the other yellow species have primarily been reported in North America and Europe, whereas *R. obtusa* is confirmed through our two-gene molecular phylogenetic analysis to be distinct from other yellow *Ramaria* species. The species most closely related to *R. obtusa* is *R. flavescentoides*. These two species share similar coloration, basidiospores sizes, and exhibit comparable features of a stout stipe and crowded branches. However, a key distinction lies in the branching pattern: *R. flavescentoides* has shorter internodes, and the branches are more dispersed, whereas *R. obtusa* has longer internodes and branches that are subparallel.

Ramaria ser. *Formosae* Corner, Beih. Nova Hedwigia 33: 240 (1970)

Synonym: *Ramaria* sect. *Formosae* (Corner) Franchi & M. Marchetti.

Type species: *R. formosa* (Pers.) Quél., Fl. mycol. France (Paris): 466 (1888)

Diagnosis: Basidiomata are pale yellow to dark yellow in tone; branches are subparallel, with off-white apices; basidia base and hyphae have clamps; basidiospores are conspicuously rough.

Commentary: This series includes three species collected in China, but the type species *R. formosa* is not founded in China. This series is characterized by white apices and basidiomata ranging from yellow to ochre-yellow color.



Fig. 63 Basidiospore features of *R. obtusa* (MHHNU 10553). Scale bar: a = 10 μm .

34. *Ramaria formosoides* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 20 (2024) Fig. 18 a–b and Fig. 64

Description: *Basidiomata* 15 cm high and 9 cm broad.

Stipe 1–3.2 $\times$ 5.5 cm, off-white at base, cream to salmon; not changing color or slightly changing color to brownish yellow to yellow ochre on bruising; surface tomentose, gnarled or rugose; without abortive branches; context of stipe off-white

to cream, freshy-fibrous, drying chalky-friable, brittle. *Major branches* several, cream to salmon. *Branches* in 3–6 ranks, butter yellow to salmon when young, apricot yellow at age; axils broadly rounded, mostly U-shaped; internodes diminishing gradually at maturity. *Apices* acute to rounded, crowded, polychotomous, off-white when young, darker at age. Odor and taste faintly fabaceous.

Basidiospores [30/2/1] 9.0–12.0(–13.0) × 4.5–5.2 (–5.5) μm , $L_m = 10.64 \mu\text{m}$, $l_m = 4.84 \mu\text{m}$, $Q = (1.8\text{--})1.9\text{--}2.5(2.6)$, $Q_m = 2.20 \pm 0.19$, subcylindrical; ornamented with conspicuously warts, cyanophilous warts. *Basidia* 45–65 × 8–12 μm , clavate, with basal clamps; sterigmata mostly 4, 3–7 μm long, incurved or straight, slightly divergent. *Subhymenium* rudimentary, hyphae, interwoven, thin walled, with clamps. *Hymenium* unthickening. *Contextual hyphae*: Tramal hyphae of stipe 4–11 μm wide, hyaline, loosely interwoven, inflating slightly; tramal hyphae of branches central hyphae slightly lysing; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae occasionally.

Ecology: Found in coniferous and broad-leaved mixed forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest, north and northeast of China (Yunnan, Sichuan, Jilin, Shanxi).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La City, Haba Snow Mountain, Mianshaba, altitude 3100 m, 12 August 2008, Li P. Tang 588 (HKAS 54819); same city, Deqin County, Baima Snow Mountain Nature Reserve, altitude 3750 m, 18 August 2018, P. Zhang 3467 (MHHNU 9967). SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 5 September 2021, P. Zhang 4259 (MHHNU 107659), P. Zhang 4260 (MHHNU 10760), P. Zhang 4276 (MHHNU 10776), P. Zhang 4277 (MHHNU 107677); same location, 6 September 2021, P.

Zhang 4287 (MHHNU 107687), P. Zhang 4291 (MHHNU 10791), P. Zhang 4300 (MHHNU 10300), P. Zhang 4305 (MHHNU 107305); same location, 7 September 2021, P. Zhang 4367 (MHHNU 107867); same location, 8 September 2021, P. Zhang 4379 (MHHNU 10879). JILIN PROVINCE: Tonghua County, Baijifeng National Forest Park, in broadleaf forest, altitude 800 m, 6 August 2022, P. Zhang 4701 (MHHNU 11201).

Commentary: Dr. Zhang identified this species as *R. obtusissima* (Peck) Corner (Zhang 2010). In Corner's 1950 description (Corner 1950), *R. obtusissima* was considered a complex group, including five different types: rough spored form, pink form, vivescent form, rich yellow, and typical (Corner 1950). In 1967, Petersen, redescribed the type specimen and restricted *R. obtusissim*. However, in 1992, Schild reexamining the type specimen, found that the basidiospores of *R. obtusissima* were not smooth as previously described, but had significant warty ornamentation (Schild 1992b). He assigned those fungi with smooth basidiospores, previously considered *R. obtusissima*, to a new species named *R. schildii*. Compared to the fine rough basidiospores of the type species *R. obtusissima*, the ornamentation of this species is significantly rougher. Moreover, this species has a wider distribution in China, although some basidiomata have rounded apices similar to *R. obtusissima*, basidiomata with acute apices are more common.

The white to creamy apices of *R. formosoides* are compared to *R. formosa*, with the latter having distinctly yellow apices. Compared to the *R. pallidicarnea*, it has slightly larger basidiospores (9.85 × 4.06 μm , as measured in this study). Compared to *R. longicarnea*, the basidiospores are slightly smaller (11.45 × 6.10 μm , as measured in this study).



Fig. 64 Basidiospore features of *R. formosoides* (MHHNU 10760). Scale bar: a = 10 μm .

35. ***Ramaria longicarnea*** P. Zhang & J. Zhong, **sp. nov.** Fig. 18 c–d and Fig. 65

Mycobank: MB 853141

Etymology: “*longicarnea*” = “*long-*” + “*carnea*”, proposed because this species has long stipes and pink to salmon color of basidiomata.

Diagnosis: Basidiomata are salmon to fleshy in color; basidia and hyphae have clamps; stipe is long with white rugulose hyphae; basidiospores are broad, strongly cyanophilous, and rough in outline.

Type: CHINA, YUNNAN PROVINCE: Dali, Binchuan County, Jizu Mountain, with broad-leaved, coniferous, or mixed forests, altitude 2300 m, 29 August 2022, P. Zhang 4829 (Holotype, MHHNU 11329, GenBank Acc. No.: ITS = PP467291, nrLSU = PP493593, *tef1*- α = PP480451).

Description: *Basidiomata* 13 × 5.5 cm. *Stipe* 7 × 1.5 cm, single, off-white (1A1) at base, salmon (6A4) upward, tapering gradually downward, with abortive branchlets; flesh solid, off-white (1A1), moist, but not gelatinous or slippery. *Major branches* 3–5, stout, crowded, small branching angle, nearly terete. *Branches* in 3–6 ranks, ascending, small branching angle, crowded, cream (4A3) to salmon (6A4), fleshy, drying soft, easily penetrated; internodes length ratio diminishing gradually at maturity; axils mostly acute, V-shaped. *Apices* crowded and acute, cuspidate, off-white (1A1) when young, finally concolorous with branches. Odor and taste faintly fabaceous.

Basidiospores [64/2/2] (9.2–)9.7–13.2(–15.6) × (4.7–)5.1–7.3(–7.9) μm , $L_m = 11.45 \mu\text{m}$, $l_m = 6.10 \mu\text{m}$, $Q = 1.59\text{--}2.32$, $Q_m = 1.92 \pm 0.16$, ellipsoid, roughened in profile; wall up to 0.3 μm

thick, strongly cyanophilous; hilar appendix prominent; ornamentation of prominent, discrete, low warts and short ridges randomly placed. *Basidia* 38–45 × 5–9 µm, clavate, clamped at base, strong cyanophilous, 4-spored; sterigmata 4–6 µm long. *Subhymenium* rudimentary, hyphal. *Hymenium* unthickening. *Tramal hyphae of stipe* 4–10 µm wide, hyaline, thin-walled to thick-walled, loosely parallel, clamped, interwoven; ampulliform clamps up to 13 µm broad, asymmetrical, thick-walled, with coarse ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* 3–10 µm wide, hyaline, clamped, thin-walled to thick-walled, loosely parallel; ampulliform clamps up to 13 µm broad, asymmetrical, thick-walled, with coarse ornamentation; gloeoplerous hyphae not observed.

Ecology: Solitary on soil in mixed forests dominated by Fagaceae and Pinaceae.

Distribution: known from southwestern China (Yunnan).

Additional materials examined: CHINA YUNNAN

PROVINCE: Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved forest, altitude 2350 m, 21 August 2022, P. Zhang 4731 (MHHNU 11231), P. Zhang 4749 (MHHNU 11249); same location, Mouding County, Huafo Mountain, 27 July 2021, Z. H. Chen 32918 (MHHNU 32918), Z. H. Chen 32921 (MHHNU 32921); Kunming, bought from mushroom market, 23 July 2017, P. Zhang 2600 (MHHNU 9100).

Commentary: Compared with *R. pallidicarnea* (basidiospores 9.85 × 4.06 µm, as measured in this study) and *R. formosoides* (10.64 × 4.84 µm, as measured in this study), it has slightly larger basidiospores and a longer stipes. *Ramaria atkinsonii* (Petersen 1984) and *R. formosa* resembles *R. longicarnea* in appearance, they share salmon to yellow basidiomata and clamped basia. Longer stipe can separate *R. formosa* and *R. longicarnea*, and the later have off-white apice when young. *Ramaria atkinsonii* and *R. longicarnea* have the same sized basidiospores, however, the former has near smooth to finely rough spore.

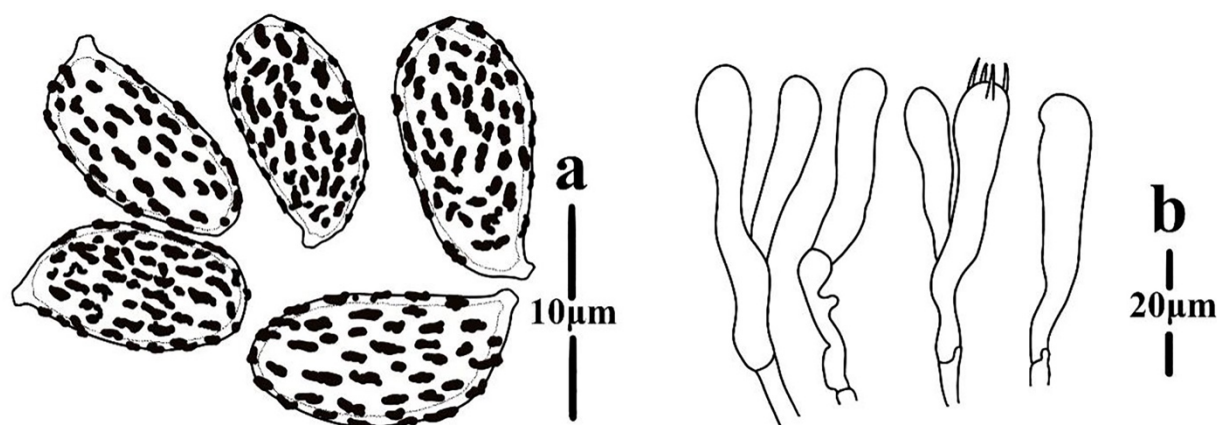


Fig. 65 Microscopic features of *R. longicarnea* (MHHNU 11329). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

36. *Ramaria pallidicarnea* P. Zhang & Xue L. Gao, **sp. nov.** Fig. 18 e–f and Fig. 66

Mycobank: MB 853138

Etymology: *pallidicarnea* = *pallida* + *carnea*, referring to its off-white apices and salmon to pink basidiomata.

Diagnosis: Apices are off-white to cream; basidiomata pink to salmon; hyphae and basidia base have clamps; drying results in a brittle and chalky-friable texture; does not change color or slightly change color to brownish yellow.

Type: CHINA, YUNNAN PROVINCE: Lijiang City, Shuhe Ancient Town, in a mixed coniferous and broad-leaved forest, altitude of 3172 m, 22 August 2020, Li P. Tang HT469 (Holotype, MHKMU HT469, GenBank Acc. No.: ITS = PP467293).

Description: *Basidiomata* 12 cm high and 7 cm broad. *Stipe* 2 × 2 cm, lobed or muscled; off-white (1A1) at base, cream (4A3) to salmon (6A4); not changing color or slightly changing color to brownish yellow (5B3) to yellow ochre (5C7) on bruising; surface tomentose, gnarled or rugose; without abortive branches; context of stipe off-white (1A1) to cream (4A3), freshly-fibrous, drying chalky-friable, brittle. *Major branches* several, cream (4A3) to salmon (6A4). *Branches* in 3–6 ranks, butter yellow (4A5) to salmon (6A4) when young, apricot yellow (5B6) at age; axils broadly rounded, mostly U-shaped; internodes diminishing gradually at maturity. *Apices* acute to rounded, crowded, polychotomous, off-white (1A1) when young, darker at age. Odor and taste faintly fabaceous.

Basidiospores [30/2/1] (8.3–)8.7–11.0(–11.7) × (3.1–)3.4–4.9(5.0) µm, $L_m = 9.85$ µm, $l_m = 4.06$ µm, $Q = 2.10$ –2.87(–3.00), $Q_m = 2.45 \pm 0.26$, subcylindrical; ornamented with conspicuously warts, cyanophilous warts. *Basidia* 45–65 × 7–12 µm, clavate, with basal clamps; sterigmata mostly 4, 3–7 µm long, incurved or straight, slightly divergent. *Subhymenium* rudimentary, hyphae, interwoven, thin walled, with clamps. *Hymenium* unthickening. *Contextual hyphae:* *Tramal hyphae of stipe* 4–11 µm wide, hyaline, loosely interwoven, inflating slightly; *tramal hyphae of branches* central hyphae slightly lysing; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae occasionally.

Ecology: Found in coniferous and broad-leaved mixed forests. *Basidiomata* occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional material examined: CHINA, YUNNAN PROVINCE: Chuxiong, Lufeng City, Tuoan Township, 6 September 2022, Xue L. Gao 20586 (MHHNU 11635).

Commentary: The isotype specimen HKAS 17744, which Petersen (1989) classified as *R. laeviformosoides*, cannot be attributed to that species because it exhibits distinctly warty basidiospores, whereas *R. laeviformosoides* is characterized by nearly smooth basidiospores. Consequently, the original isotype HKAS 17744 is described here as a new species, *R. pallidicarnea*. *Ramaria pallidicarnea* is distinguished from other species in ser. *formosae* by its average basidiospores length being less than 10 µm.

Ramaria ser. *Gelatinosae* P. Zhang & J. Zhong, **ser. nov.**

MycoBank: MB 852719

Etymology: “gelatinose” means the stipe somewhat gelatinous.

Type species: *R. indoyunnaniana* R.H. Petersen & M. Zang, Acta bot. Yunn. 8(3): 287, 1986.

Diagnosis: Basidiomata are pale yellow to salmon, with apices yellow to pink; stipe is somewhat gelatinous or slippery; branches are slender; most species lack clamps.

Commentary: This series includes fifteen species

collected in China, including *R. pallidosaponaria* R.H. Petersen 1989, *R. flavigelatinosa* Marr & D.E. Stuntz, *R. flavoides* Schild and its varieties *R. flavoides* var. *betonensis* Franchi & M. Marchetti (= *R. abetonensis* Franchi & M. Marchetti), *R. verlotensis* Marr & D.E. Stuntz, *R. ossolana* Franchi & M. Marchetti, *R. primulina* R.H. Petersen, *R. gelatiniaurantia* Marr & D.E. Stuntz and its varieties *R. gelatiniaurantia* var. *violeitingens* Marr & D.E. Stuntz, *R. gelatiniaurantia* var. *gelatiniaurantia* Marr & D.E. Stuntz.

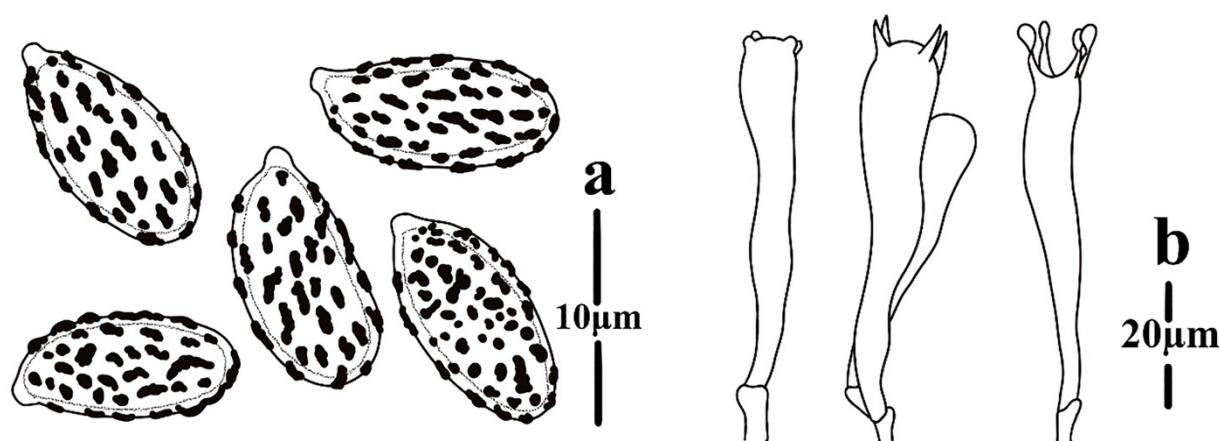


Fig. 66 Microscopic features of *R. pallidicarnea* (MHHNU 11635). a basidiospores; b basidia. Scale bars: a=10 μm, b=20 μm.

37. ***Ramaria apicaliochracea*** L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 14 (2024)

Original description in Li et al. (2024).

38. ***Ramaria brevigelatinosa*** P. Zhang & J. Zhong, **sp. nov.** Fig. 19 a–b and Fig. 67

MycoBank: MB 853036

Etymology: *brevigelatinosa* = *brevi-* + *gelatinosa*, where “*brevi-*” refers to the stipe being short, and “*gelatinosa*” means the species has a gelatinous context.

Diagnosis: Basidiomata are small to medium sized and pale yellow; stipe is short, stout, gelatinous, and smooth; hyphae and basidia base lack clamps; average basidiospores length is smaller than 10 μm.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Zixi Mountain, in mixed forests dominated by Fagaceae and Pinaceae, altitude 2100 meters, 24 August 2022, P. Zhang 4783 (Holotype, MHHNU 11283, GenBank Acc. No.: ITS = PP467184, nrLSU = PP493505).

Description: *Basidiomata* 3–6 × 1.5–3.5 cm, fasciculate habit, usually obpyriform to broadly fusiform in outline. *Stipes* up to 0.5 × 1.5 cm, single to compound, tapering gradually downward; milk white (1A2) at base, milk white (1A2) to pale yellow (2A3) upward; surface smooth; with abortive branches; some region changing color to brownish gray (6E2) on bruising or purple spots caused by soil particles; context of stipe off-white (1A1) to jelly-like pastel yellow (2A4) when fresh, drying light in weight, easily penetrated, gelatinous, hard. *Major branches* several, ascending, terete. *Branches* in 3–5 ranks, major branches and lower branches commonly dichotomous; branches pale yellow (2A3) to chicken yellow (2A6); axils broadly rounded, mostly U-shaped; internodes all

short; branches terete, sparsely, subparallel upward; context of main branches and upper branches gelatinous, viscid, brittle, pastel yellow (2A4). *Apices* broadly rounded, molar-like when young, terraced, short-digitate at maturity, concolorous with branches or slightly pale yellow (2A3) to chicken yellow (2A6). Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [50/2/2] (8.5–)9.0–11.0(–11.5) × 4.5–5.8(–6.0) μm, $L_m = 9.92$ μm, $l_m = 5.21$ μm, $Q = (-1.61)1.77-2.29(-2.33)$, $Q_m = 2.01 \pm 0.15$, ellipsoid, noticeably rough; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 45–65 × 6–8 μm, clavate, without basal clamps; sterigmata 4, 3–6 μm long, short and straight, somewhat scattered. *Hymenium* unthickening, 50–70 μm. *Subhymenium* extensive, hyphae, interwoven, 1–3 μm diam, adherent, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 3–10 μm wide, hyaline, tightly interwoven, heavily agglutinated, ampulliform inflations occasionally; tramal hyphae of branches central hyphae slightly narrow, 2–10 μm, hyaline, thin-walled, agglutinated, strictly parallel, tightly packed, ampulliform inflations rare; gloeoplerous hyphae common, 4–8 μm diam.

Ecology: Solitary or gregarious on soil in mixed forests dominated by Fagaceae and Pinaceae. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Huafo Mountain, in the mixed forests, altitude 2200 m, 23 August 2022, P. Zhang 4769 (MHHNU 11269); same locaiton, altitude 2300 m, 21 August 2022, P. Zhang 4748 (MHHNU 11248); Chuxiong, Shuangbaisi, 22 August 2018, Zuo H. Chen 31306 (MHHNU 31306); Kunming,

Panlong District, A Ziyang, 2 August 2001, P. Zhang 128 (MHHNU 6628); Wenshan, Malipo County, Xinzhai Township, in broad-leaved forest, altitude 1566 m, 27 July 2017, G. Wu 2207 (HKAS123447), G. Wu 2208 (HKAS123448).

Commentary: Species with a closer affinity to *R. brevigelatinosa* include *R. thindii*, and *R. hunanensis*. These species share common features such as yellow basidiomata, gelatinous context, and absence of clamps. Molecular

phylogenetic analysis confirms that they are not the same species. Microscopically, only *R. brevigelatinosa* and *R. hunanensis* (basidiospore $11.51 \times 5.70 \mu\text{m}$, as measured in this study) exhibit a slightly smaller length-to-width ratio of basidiospores compared to the others, with the former having even smaller basidiospores dimensions. Additionally, *R. brevigelatinosa* is characterized by shorter and stouter stipes, and relatively fat branches.

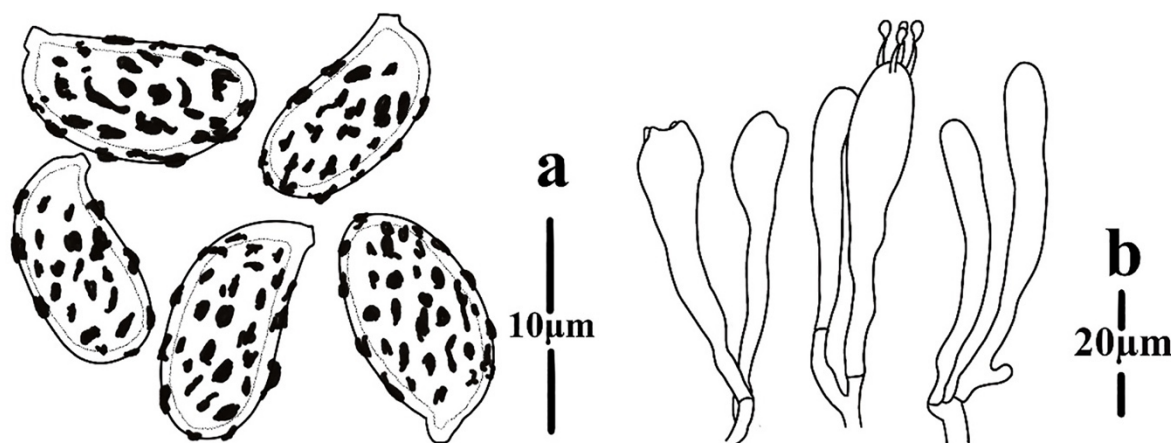


Fig. 67 Microscopic features of *R. brevigelatinosa* (MHHNU 11283). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

39. *Ramaria hunanensis* P. Zhang & J. Zhong, **sp. nov.** Fig. 19 c–d and Fig. 68

MycoBank: MB 853374

Etymology: *hunanensis*, indicating that the species is collected in the Hunan Province of China and is characterized by its yellow basidiomata and gelatinous flesh features.

Diagnosis: Basidiomata are overall light-yellow in color; stipe is slender, gelatinous, and smooth; changes color to fawn brown on bruising; hyphae and basidia base lack clamps; basidia are elongated, and basidiospores relatively large.

Type: CHINA, HUNAN PROVINCE: Chenzhou City, Yizhang County, Mangshan National Nature Reserve, in mixed forests dominated by Fagaceae and Pinaceae. altitude 1500 m, 2 September 2007, P. Zhang 640 (Holotype, MHHNU 7140, GenBank Acc. No.: ITS = PP467189, nrLSU = PP493509, *tef1-a* = PP480391).

Description: *Basidiomata* 2–8 × 1.5–7 cm, fasciculate habit. *Stipes* up to 2–4 × 1–2 cm, single to compound, slender, tapering gradually downward; milk white (1A2) to chicken yellow (2A6); changing color to fawn brown (7E4) on bruising; surface smooth; without abortive branches; context of stipe off-white (1A1) to jelly-like pastel yellow (2A4) when fresh, drying light in weight, easily penetrated, gelatinous, brittle. *Major branches* several, ascending, terete. *Branches* in 2–5 ranks, major branches and lower branches commonly dichotomous; branches milk white (1A2) to chicken yellow (2A6); axils broadly rounded, mostly U-shaped; internodes long, diminishing gradually at maturity; branches terete, strict, sparsely, subparallel upward; context of main branches and upper branches gelatinous, viscid, brittle, pale yellow (2A3). *Apices* broadly rounded, 1–3 mm long, fragile, dichotomous, milk white (1A2) to pastel yellow (2A4). Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2] 10.0–13.0(–14.0) × 4.0–7.0 μm , L_m =

11.51 μm , l_m = 5.70 μm , Q = (1.67)–1.71–2.75, Q_m = 2.05 ± 0.26, subcylindrical to long ellipsoid, noticeably rough; ornamented with moderate warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 53–80 × 8–13 μm , clavate, without basal clamps; sterigmata 4, 6–9 μm long, long and straight, somewhat scattered. *Hymenium* unthickening, 60–90 μm . *Subhymenium* extensive, hyphae, interwoven, 1.5–3 μm diam, adherent, without clamps. *Contextual hyphae:* Tramal hyphae of stipe 2–14 μm wide, hyaline, tightly interwoven, heavily agglutinated, ampulliform inflations up to 17 μm ; tramal hyphae of branches central hyphae slightly narrow, 2–12 μm , hyaline, thin-walled, agglutinated, strictly parallel, tightly packed, ampulliform inflations associated with septa, up to 17 μm broad, thick-walled (wall up to 1 μm thick), unornamented; gloeoplerous hyphae commonly, 4–8 μm diam.

Ecology: Solitary or gregarious on soil in mixed forests dominated by Fagaceae and Pinaceae. Basidiomata occurs in summer and autumn.

Distribution: Known from central China (Hunan).

Additional materials examined: CHINA, HUNAN PROVINCE: Chenzhou City, Yizhang County, Mangshan National Nature Reserve, in mixed forests dominated by Fagaceae and Pinaceae. 26 July 2018, P. Zhang 3227 (MHHNU 9727); same location, Guizizhai, in broad-leaved forest with Fagaceae, 14 September 2003, P. Zhang 375 (MHHNU 6875), P. Zhang 376 (MHHNU 6876), P. Zhang 377 (MHHNU 6877).

Commentary: Within the group of taxa with light yellow to yellow gelatinous features and no clamps, there are species such as *R. verlotensis* Marr & D. E. Stuntz, *R. flavigelatinosa*, and its variants. *Ramaria verlotensis* has cauliflower-like, pale yellowish pink basidiomata, and its basidiospores are slightly smaller (9.0–11.0 × 4.5–6.0 μm , L_m = 10.1 μm , l_m = 4.9 μm , Q_m

= 2.06; Marr & Stuntz 1973). *Ramaria flavigelatinosa* has a white base of the fruiting body, branches ranging from light yellow to maize yellow, and apices concolorous with branches or slightly brighter, resembling sunflower yellow. However, its basidiospores are shorter than 10 μm (9.6 $\times$ 4.1 μm ; Marr & Stuntz 1973). *Ramaria flavigelatinosa* var.

megalospora, has basidiospores sizes similar to *R. hunanensis*, but its fruiting body tends towards melon yellow, slightly more orange yellow, unlike the yellowish-white color of *R. hunanensis*. Importantly, *R. hunanensis* shows purple-brown bruising where it contacts soil particles.

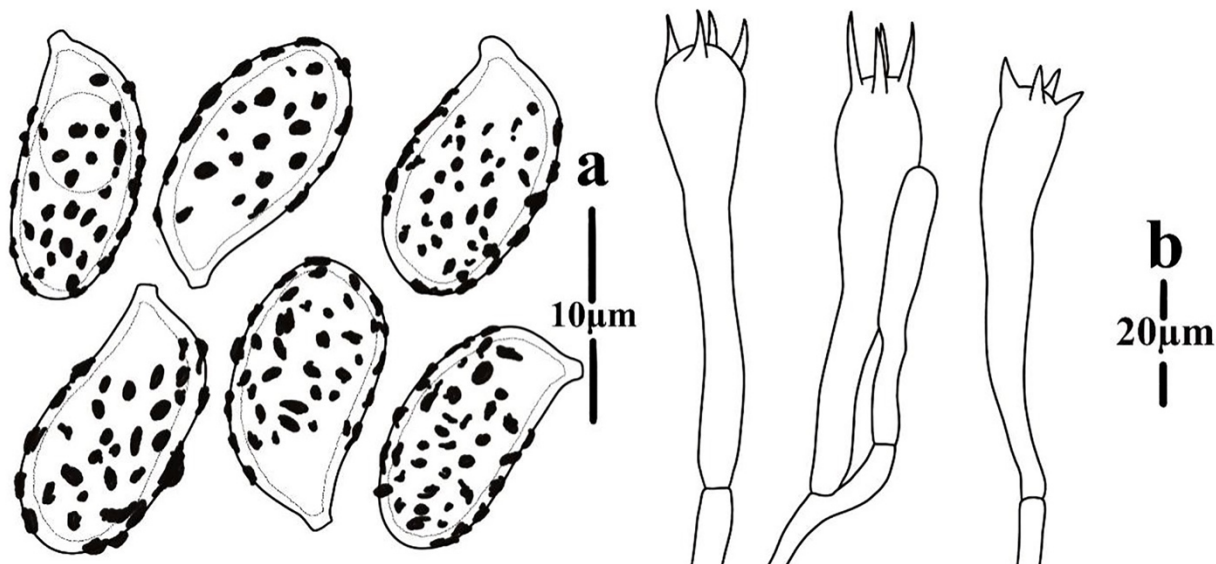


Fig. 68 Microscopic features of *R. hunanensis* (MHHNU 7140). a basidiospores; b basidia. Scale bars: a =10 μm , b = 20 μm .

40. *Ramaria flavicoralloides* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 19 (2024)
Original description in Li et al. (2024).

41. *Ramaria gelatinifusca* P. Zhang & J. Zhong, **sp. nov.** Fig. 19 e–f and Fig. 69

Mycobank: MB 853376

Etymology: *gelatinifusca* = *gelatinosa* + *fusca*, indicating that the species has a gelatinous stipe and changes color to

brown when bruised.

Diagnosis: Basidiomata are salmon color; apices are broadly rounded, yellow to salmon; stipe is gelatinous, gnarled or rugose; hyphae and basidia base are nearly without clamps; basidiospores are broad.

Type: CHINA, YUNNAN PROVINCE: Deqin County, Baima Snow Mountain Nature Reserve, 17 August 2018, P. Zhang 3436 (Holotype, MHHNU 9936, GenBank Acc. No.: ITS = PP467193, nrLSU = PP493513).

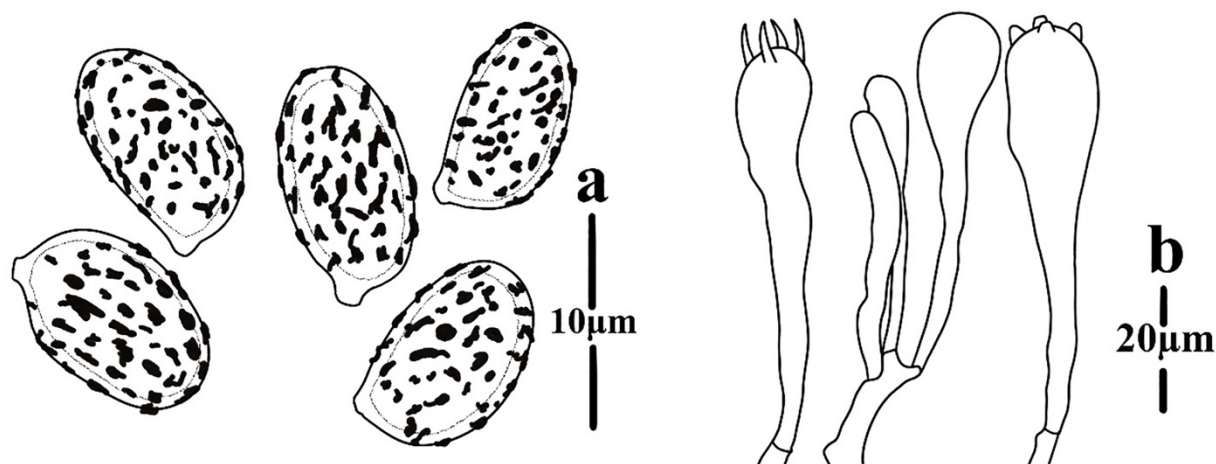


Fig. 69 Microscopic features of *R. gelatinifusca* (MHHNU 9936). a basidiospores; b basidia. Scale bars: a =10 μm , b = 20 μm .

Description: *Basidiomata* 9–15 $\times$ 8–12 cm, fasciculate habit. *Stipes* up to 4 $\times$ 5 cm, single to compound, tapering

gradually downward; off-white (1A1) at base, light orange (5A3) to yellowish orange (4A8); changing color to brownish gray

(6E2) on bruising; longitudinally gnarled or rugose; occasionally with abortive branches; context of stipe off-white (1A1) to jelly-like yellowish orange (4A8) when fresh, drying light in weight, easily penetrated, gelatinous, firm. *Major branches* several, ascending, hardly terete. *Branches* in 3–5 ranks, major branches and lower branches commonly polychotomous; branches salmon (6A4) to yellowish orange (4A8); axils narrowly rounded, mostly V-shaped; internodes long, diminishing gradually at maturity; branches terete, sparsely, subparallel; context of main branches and upper branches semi-gelatinous, viscid, brittle, yellowish orange (4A8). *Apices* broadly rounded, 1–3 mm long, fragile, polychotomous, pale orange (5A3) to chicken yellow (2A6). Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [30/2/1] (9.0–)10.5–13.7(–14.2) × (4.2–)4.8–6.6(–7.2) µm, $L_m = 11.71$ µm, $l_m = 5.68$ µm, $Q = (1.73\text{--})1.83\text{--}2.36(–2.43)$, $Q_m = 2.07 \pm 0.18$, subcylindrical to ellipsoid, moderately rough; ornamented with moderate warts and short meandering ridges randomly placed, moderately cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 55–75 × 7–15 µm, clavate, without basal clamps; sterigmata 4, 3–6 µm long, slender and straight, somewhat scattered. *Hymenium* unthickening, 60–80 µm. *Subhymenium* extensive, hyphae, interwoven, 1.5–3 µm diam, adherent, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 2–14 µm wide, hyaline, tightly interwoven, heavily agglutinated, ampulliform inflations up to 15 µm; tramal hyphae of branches central hyphae slightly narrow, 2–12 µm, hyaline, thin-walled, agglutinated, strictly parallel, tightly packed, ampulliform inflations associated with septa, up to 15 µm broad, thick-walled (wall up to 1 µm thick), unornamented; gloeoplerous hyphae commonly, 4–8 µm diam.

Ecology: In the mixed forests dominated by *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La City, Pudacuo National Park, Bitahai, in the *Picea* forest, altitude 3500 m, 31 August 2022, P. Zhang 4847 (MHHNU 11347); Deqin County, Baima Snow Mountain Nature Reserve, in the *Picea* forest, altitude 3750 m, 18 August 2018, P. Zhang 3468 (MHHNU 9968); same location, 17 August 2018, P. Zhang 3441 (MHHNU 9941).

Commentary: The species with salmon-colored basidiomata, gelatinous stipe, and lacking clamps are quite numerous. The most similar species is *R. linearis*, and the wider basidiospores (13.56 × 5.14 µm, as measured in this study) and bruising to grayish brown are the distinguishing features of *R. gelatinosivivida*, making it easily distinguishable from other species. This species is collected in relatively humid high-altitude areas with *Picea* forests, and it is prone to mold, producing gray-brown spots. The abundant gelatinous substance imparts a jelly-like semi-translucent quality to the stipe flesh, and the branching tissue exhibits a red-orange color.

42. *Ramaria gelatinosivivida* P. Zhang & J. Zhong, **sp. nov.** Fig. 19 g–h and Fig. 70

Mycobank: MB 853377

Etymology: *gelatinosivivida* = *gelatinosa* + *vivida*, referring to the species having a vivid yellow color and gelatinous stipe and branches.

Diagnosis: Basidiomata are vivid yellow to salmon colored; apices are broadly rounded, concolorous with branches, and slightly brownish by maturity; stipe is gelatinous, gnarled or rugose; hyphae and basidia base are nearly without clamps; basidiospores are ornamented with moderate warts, long and narrow.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3500 m, 2 September 2018, P. Zhang 3589 (Holotype, MHHNU 10089, GenBank Acc. No.: ITS = PP467195, nrLSU = PP493515).

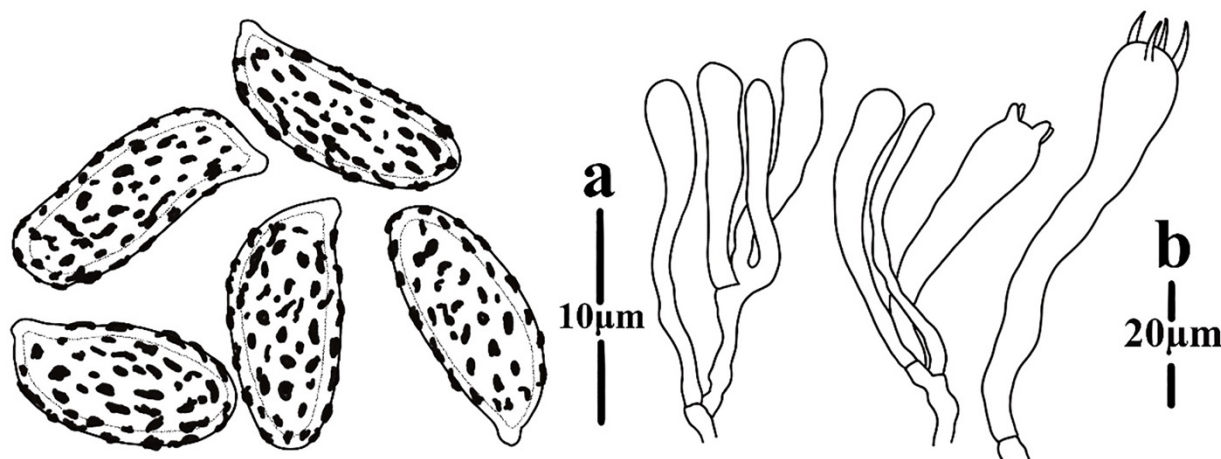


Fig. 70 Microscopic features of *R. gelatinosivivida* (MHHNU 10089). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 8–10 × 15 cm, single to fasciculate habit. *Stipes* up to 3–5 × 3–6 cm, single to compound, stout, tapering gradually downward; off-white (1A1) at base, off-white (1A1) to vivid yellow (2A8); not changing color on bruising; longitudinally gnarled or rugose; with abortive branches; context of stipe off-white (1A1) to

pale yellow (62A3) when fresh, drying light in weight, easily penetrated, gelatinous, firm. *Major branches* several, ascending, hardly terete. *Branches* in 3–5 ranks, major branches and lower branches commonly polychotomous; branches pale yellow (2A3) to vivid yellow (2A8), sometimes cream (4A3) to salmon (6A4); axils narrowly rounded, mostly

V-shaped; internodes all short, branches terete, ascending; context of main branches and upper branches semi-gelatinous, viscid, brittle, pastel yellow (2A4). *Apices* broadly rounded, 1–3 mm long, fragile, polychotomous, concolorous with branches, with slightly grayish orange (6B5) at maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [90/3/3] (9.4–)10.5–12.9(–14.2) × (4.1–)4.3–5.5(–5.9) μm , $L_m = 11.64 \mu\text{m}$, $l_m = 4.80 \mu\text{m}$, $Q = (1.94\text{--})2.06\text{--}2.77\text{--}(2.90)$, $Q_m = 2.43 \pm 0.23$, subcylindrical to narrowly ellipsoid; ornamented with moderate warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. **Basidia** 45–70 × 7–12 μm , clavate, without basal clamps; sterigmata 4, 3–6 μm long, short and straight. **Hymenium** unthickening, 55–80 μm . **Subhymenium** extensive, hyphae, interwoven, 1.5–3 μm diam, adherent, occasionally with clamps. **Contextual hyphae**: Tramal hyphae of stipe 2–14 μm wide, hyaline, tightly interwoven, heavily agglutinated, ampulliform inflations up to 15 μm ; tramal hyphae of branches central hyphae slightly narrow, 2–12 μm , hyaline, thin-walled, agglutinated, strictly parallel, tightly packed, ampulliform inflations associated with septa, up to 15 μm broad, thick-walled (wall up to 1 μm thick), unornamented; gloeoplerous hyphae commonly, 4–8 μm diam.

Ecology: In the mixed forests dominated by *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4380 (MHHNU 10880);

same location, altitude 3500 m, 2 September 2018, P. Zhang 3581 (MHHNU 10081), P. Zhang 3583 (MHHNU 10083); same city, Shade Town, 24 August 2017, P. Zhang 2752 (MHHNU 9252).

Commentary: The basidiomata color of *R. gelatinosivivida* is similar to *R. ephemeroderma*, both of which have gelatinous stipes, lack clamps, and exhibit yellow to salmon-colored basidiomata. However, it differs from the latter in having larger basidiospores dimensions and a higher length-to-width ratio (11.91 × 4.47 μm , $Q_m = 2.67$; as measured in this study). Additionally, *R. gelatinosivivida* can be confused with some other yellow to salmon-colored species, but the wrinkled and gelatinous stipe, long and narrow basidiospores, and the vivid yellow color when fresh are crucial characteristics for identification.

43. ***Ramaria gelatinostipes*** P. Zhang & J. Zhong, **sp. nov.** Fig. 19 i–j and Fig. 71

Mycobank: 853035

Etymology: *gelatinostipes* = *gelatinosa* + *stipes*, indicating that the species has a gelatinous stipe.

Diagnosis: Basidiomata are cream color; stipe is short with abortive branches, context is hard and gelatinous, heavily agglutinated; apices are broadly rounded and concolorous with branches; hyphae and basidia base exhibit clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4326 (Holotype, MHHNU 10826, GenBank Acc. No.: ITS = PP467197, nrLSU = PP493517, *tef1-a* = PP480394).

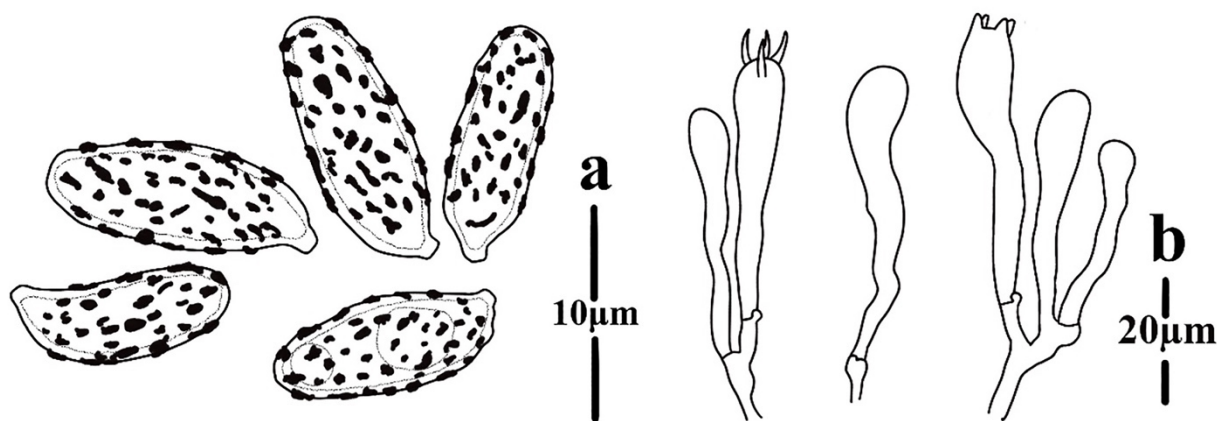


Fig. 71 Microscopic features of *R. gelatinostipes* (MHHNU 10826). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Description: **Basidiomata** 8–11 cm high and 5–8 cm broad, single to fasciculate habit. **Stipe** 2–4 × 2–4 cm, single to compound, stout; off-white (1A1) at base, off-white (1A1) to pale yellow (2A3); not changing color on bruising; surface smooth; with abortive branches; context of stipe off-white (1A1) when fresh, drying light in weight, easily penetrated, gelatinous, firm. **Major branches** 2–4, curved-ascending, hardly terete. **Branches** in 3–5 ranks, major branches and lower branches commonly polychotomous; branches pale yellow (2A3) to cream (4A3); axils narrowly rounded, mostly V-shaped; internodes diminishing gradually at maturity, lower

internodes to 3 cm; branches commonly 2–15 mm, terete, ascending; context of main branches and upper branches semi-gelatinous, viscid, brittle, pastel yellow (2A4). *Apices* broadly rounded, 1–3 mm long, fragile, polychotomous, concolorous with branches. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [63/2/2] (–8.7)8.9–11.1(–11.6) × (3.1–)3.5–5.1(–5.4) μm , $L_m = 9.79 \mu\text{m}$, $l_m = 4.37 \mu\text{m}$, $Q = (–1.90)1.98\text{--}2.73\text{--}(3.30)$, $Q_m = 2.29 \pm 0.17$, subcylindrical to narrowly ellipsoid; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar

conspicuous, slightly curved. *Basidia* 40–55 × 8–10 µm, clavate, with basal clamps; sterigmata 4, 3–6 µm long, short and straight. *Hymenium* unthickening, 55–65 µm. *Subhymenium* extensive, hyphae, interwoven, 1.5–3 µm diam, adherent, with clamps. *Contextual hyphae*: Tramal hyphae of stipe 2–14 µm wide, hyaline, tightly interwoven, heavily agglutinated, ampulliform inflations not observed; tramal hyphae of branches central hyphae slightly narrow, 2–12 µm, hyaline, thin-walled, agglutinated, strictly parallel, tightly packed, ampulliform inflations associated with septa, up to 15 µm broad, thick-walled (wall up to 1 µm thick), unornamented; gloeoplerous hyphae commonly, 4–8 µm diam.

Ecology: In the mixed forests dominated by *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 5 September 2021, P. Zhang 4355 (MHHNU 10855), P. Zhang 4362 (MHHNU 10862).

Commentary: The species most similar to *R. gelatinostipes* is *R. ossolana* Franchi & M. Marchetti and *R. flavoides* Schild and its original variety. These species all have basidiomata with a light yellow to cream color, gelatinous flesh, and the presence of clamps. The differences lie in the fact that *R. ossolana* has a spicy taste, an unpleasant odor, and slightly smaller basidiospores (9.3 × 4.3 µm; Franchi & Marchetti 2021). The basidiomata of *R. flavoides* and its original variety tend to be bright yellow color.

44. *Ramaria indoyunnaniana* R.H. Petersen & M. Zang, Acta bot. Yunn. 8(3): 287, 1986. Fig. 19 k–l and Fig. 72

Description: Basidiomata 8 cm high and 4 cm broad, obovate in outline. Stipe discrete, short to long, fleshy, solid, without abortive branches, smooth, ivory-colored; flesh off-white, very slightly soapy when sliced and rubbed. Major branches are few, ascending but not strict, shell pink when adolescent; small soil particles causing weak wine-red spots; axils rounded. Apices more or less acute, probably terraced when young, rich muted rose when adolescent, perhaps somewhat pallid when juvenile and probably fading to pallid ochraceous in age; Odor weakly fabaceous; taste negligible; apparently edible.



Fig. 72 Basidiospore features of *R. indoyunnaniana* (MHHNU 9134). Scale bar: a = 10 µm.

Basidiospores [40/2/2] (5.7–)6.2–8.8(–9.5) × (3.1–)3.3–4.8(–4.9) µm, $L_m = 7.18$ µm, $l_m = 4.16$ µm, $Q = (1.50–)1.51–2.03(–2.04)$, $Q_m = 1.75 \pm 0.15$, cylindrical, roughened in profile; wall

up to 0.3 µm thick; hilar appendix eccentric, rarely discrete; ornamentation of obscure, hardly cyanophilous patches up to 0.2 µm high. *Basidia* 35–45 × 6–7.5 µm, clavate, without clamps; sterigmata 4, spindly, straight. *Subhymenium* extensive, hyphal. *Hymenium* thickening. *Tramal hyphae* of stipe 10 µm wide, hyaline, without clamps, probably adherent; *Tramal hyphae* of upper branches up to 8 µm wide, hyaline, thin walled, without clamps, adherent, tightly packed, strictly parallel.

Ecology: Solitary or gregarious on soil in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known in southwestern, central China and east China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Pu'er City, 20 September 1983, Petersen 45681 (isotype, HKAS 10422); Pu'er City, Menglang Town, bought from mushroom market, 30 July 2017, P. Zhang 2634 (MHHNU 9134); Wenshan, Malipo County, Xinhe Village, in broad-leaved forest with Fagaceae, altitude 1200 m, 4 August 2018, P. Zhang 3339 (MHHNU 9839).

Commentary: The species is what (Sharda 1983) referred to as *R. araiospora* var. *rubella* Marr & Stuntz. The fruiting bodies exhibit a bright pinkish red coloration, not the distinctly magenta red of *R. araiospora*, and produce somewhat smaller basidiospores compared with *R. araiospora* (9.9 × 3.7 µm; Marr & Stuntz 1973). Additionally, *R. araiospora* and other similar species *R. cyaneigranosa* Marr & Stuntz (9.6 × 4.7 µm; Marr & Stuntz 1973) typically have larger basidiomata compared to those reported by Sharda. Instead, the Asian taxon appears most similar to *R. rosella* Petersen from the southern Appalachian Mountains of eastern North America (Petersen 1985). *Ramaria rosella* shares almost identical coloration and stature but produces somewhat larger basidiospores (9.87 × 4.16 µm; Petersen 1985).

45. *Ramaria microspora* (R.H. Petersen & M. Zang) P. Zhang & J. Zhong, stat nov. et comb. nov. Fig. 19 m–n and Fig. 73

≡ *Ramaria botrytoides* var. *microspora* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 372 (1989)

Mycobank: MB 853380

Basionym: *Ramaria botrytoides* var. *microspora* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 372, 1989.

Etymology: “*microspora*” refers to the small basidiospores of the species, thus elevating “*R. botrytoides* var. *microspora*” to the rank of species “*R. microspora*”.

Isotype: CHINA, YUNNAN PROVINCE: Lijiang City, bought from mushroom market, under *Pinus armandi*, *P. yunnanensis*, and *Quercus rehderiana* mixed forest, 30 August 1986, HKAS 20072.

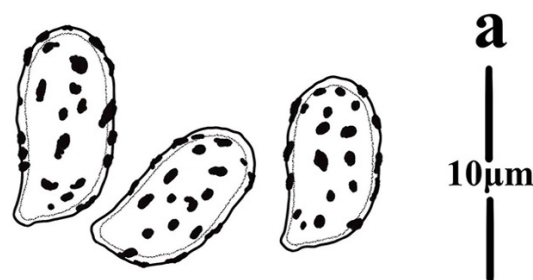


Fig. 73 Basidiospore features of *R. microspora* (MHHNU 9914). Scale bar: a = 10 µm.

Description: *Basidiomata* 8 cm high and 10.5 cm broad, single to cespitose, obtriangular in outline. *Stipes* up to 3 × 2 cm, single, tapering sharply downward to an acute or gnarled base, involving significant substrate when picked; white or off-white at base, off-white to pale yellow upward; not changing color on bruising; pruinose at stipe base, smooth upward; with abortive branchlets, abortive branchlets bright pink rose pink where protected; flesh off-white when fresh, appearing hydropachous, rubbery or firm-gelatinous, drying hard, cartilaginous. *Major branches* 2–4, curved ascending, hardly terete. *Branches* in 3–6 ranks, major branches and lower branches commonly polychotomous, orange-white when young, deepens slightly by maturity; axils narrowly rounded, mostly U-shaped; internodes diminishing gradually at maturity, lower internodes to 3 cm; branches commonly 2–10 mm, hardly terete, ascending; context of main branches and upper branches semi-gelatinous, viscid, brittle, off-white. *Apice* finely divided, 1–3 mm, delicate, double-dichotomous, rose-pink when protected or young, fading rapidly where exposed carrot red, finally concolorous with branches in age. Odor faintly fabaceous; taste negligible.

Basidiospores [22/2/2] (7.0–)7.2–9.5(–10.0) × 4.0–5.0 µm, $L_m = 8.49$ µm, $l_m = 4.32$ µm, $Q = (1.67\text{--})1.68\text{--}2.38$, $Q_m = 1.97 \pm 0.23$, short-cylindrical to broadly ellipsoid, flattened adaxially, occasionally pip-shaped, conspicuously roughened in profile; ornamentation of plate-like warts and short ridges randomly placed, strongly cyanophilous warts; hilar appendix prominent, slightly curved. *Basidia* 57–65 × 8–9 µm, clavate, without clamps at base; sterigmata 4, 4–7 µm long, slender, curved. *Hymenium* thickening, 60–85 µm. *Subhymenium* extensive, pseudo-parachymatous, 1.5–2.5 µm, adherent, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 4–12 µm wide, hyaline, thin-walled, unclamped, tightly interwoven, heavily agglutinated, ampulliform inflations not observed; tramal hyphae of branches central hyphae slightly narrow, 3–11 µm, hyaline, thin walled, agglutinating substance easily liberated into 2% KOH mounts as amorphous debris, strictly parallel, tightly packed, ampulliform inflations associated with septa, up to 13 µm broad, thick-walled (wall up to 1 µm thick), unornamented; without clamps; gloeoplerous hyphae commonly, 4–8 µm diam.

Ecology: Found in mixed forests dominated by *Quercus* or in mixed forests. *Basidiomata* occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La City, Pudacuo National Park, Bitahai, in the mixed forest with *Quercus* and *Picea*, altitude 3500 m, 31 August 2022, P. Zhang 4842 (MHHNU 11342); same location, Shudu, in the *Quercus* forests, altitude 3600 m, 15 August 2018, P. Zhang 3412 (MHHNU 9912), P. Zhang 3414 (MHHNU 9914); Qujing City, Qilin District, near Longyuan Zhumushan Wind Farm, in the broad-leaved forest, altitude 2100 m, 19 August 2022, P. Zhang 4707 (MHHNU 11207); Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, bought from mushroom market, 3 August 2001, P. Zhang 119 (MHHNU 6619), P. Zhang 120 (MHHNU 6620).

Commentary: The main features of *R. microspora* include cream-colored branches with bright rose-pink clustered apices, which retain their pink hue well when dry but may fade after maturation or due to environmental factors. The stipe is short with firmly gelatinous flesh characterized by

heavily agglutinated hyphae, often forming abortive clusters with rosy-pink apices. Hyphae and basidia base lack clamps, and basidiospores are small sized with a thickened hymenium.

Ramaria botrytoides and their original variety are distinctly different both in the field and microscopically. Widely distributed in North America and reported in China, *R. botrytoides* differs from *R. microspora* primarily in having slender basidiospores (7.0–9.5 × 3.0–3.7 µm, Corner 1950) with less pronounced ornamentation.

Despite similarities between two species collected in China and North America—such as gelatinous stipes, pink branch apices, and small basidiospores—there are notable differences. Firstly, basidiospores from the Chinese collection are smaller than the smallest basidiospores found in North American specimens. Secondly, basidiospores ornamentation in the Chinese collection is significantly more prominent compared to North American specimens. Thirdly, Chinese *basidiomata* react with several macrochemical reagents, whereas North American specimens are relatively inert.

46. *Ramaria platyrugosa* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, *Mycology*: 10.1080/21501203.2024.2388910, 26 (2024)

Original description in Li et al. (2024).

47. *Ramaria rubrisubtilis* P. Zhang & J. Zhong, **sp. nov.** Fig. 19 o–p and Fig. 74

Mycobank: MB 853379

Etymology: *rubrisubtilis* = “*rubr*” + “*subtilis*”, referring to the species having slightly red apices.

Diagnosis: Apices slightly pink colored, retaining color when dry but may lighten with mature or environment factors; stipe slender, *basidiomata* obpyramidal in outline; bruising turns slightly brownish when injured; hyphae and basidia base lack clamps.

Type: CHINA, HUNAN PROVINCE: Chenzhou City, Yizhang County, Mangshan National Nature Reserve, 5 September 2007, P. Zhang 660 (Holotype, MHHNU 7160, GenBank Acc. No.: ITS = PP467202, nrLSU = PP493521).

Description: *Basidiomata* 6.5–15 cm high and 5–12 cm broad, single to fasciculate habit, usually obovate in outline. *Stipe* 2–3 × 1–2.5 cm, single, fleshy, slender, tapering downward evenly to narrowly rounded base; off-white (1A1) at base, off-white (1A1) to pale yellow (2A3); slightly changing color to brownish yellow (5B3) on bruising; surface smooth; with abortive branches; context of stipe off-white (1A1) when fresh, drying light in weight, easily penetrated, cartilaginous, brittle. *Branches* in 3–5 ranks, major branches and lower branches commonly polychotomous, upward branches dichotomous; branches ivory (4B3) to cream (4A3) when young, surface smooth, flesh color (6A3) and rugose at age; axils narrowly rounded, mostly V-shaped; internodes diminishing gradually at maturity, lower internodes long, up to 1.5 cm; branches commonly 1–3 mm, terete, sub-parallel; context of main branches and upper branches fleshy to gelatinous, off-white (1A1). *Apices* broadly rounded, 1–2 mm long, dichotomous, shell pink (8A3) to pink (10A3) and the color remains unchanged after collecting when young, the color lighter when old or influenced by environmental factors. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

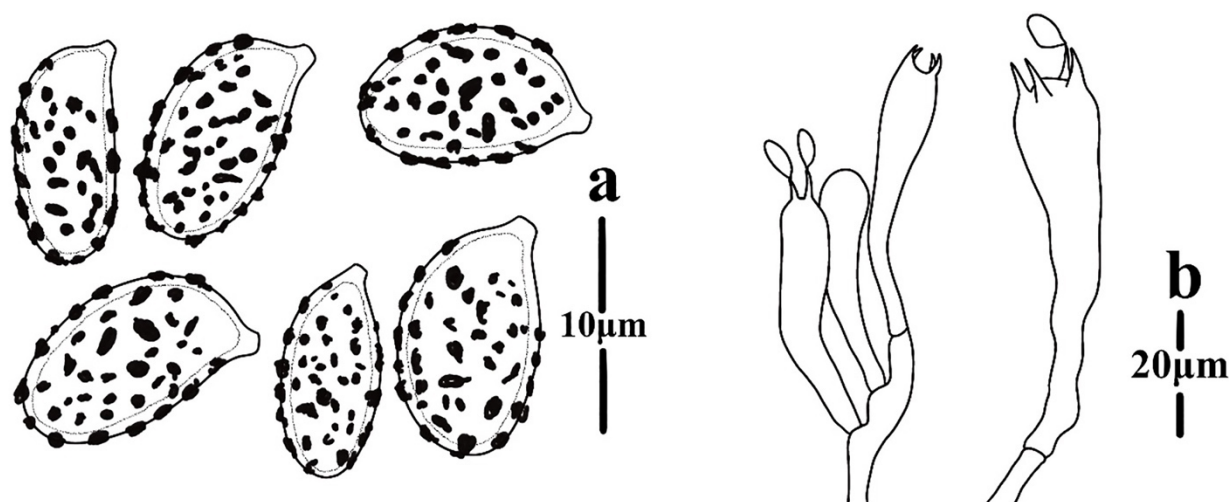


Fig. 74 Microscopic features of *R. rubrisubtilis* (MHHNU 7160). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [60/2/2] 10.0–12.0 × 4.0–6.0(–7.0) μm, $L_m = 10.76$ μm, $l_m = 5.24$ μm, $Q = 1.67$ –2.50(–2.75), $Q_m = 2.07 \pm 0.24$, subcylindrical to long ellipsoid; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. **Basidia** 46–72 × 7–12 μm, clavate, without basal clamps; sterigmata 4, 4–7 μm long, incurved or straight, slightly divergent. **Hymenium** unthickening, 45–75 μm. **Subhymenium** extensive, 10–15 μm thick, hyphae, interwoven, 3–6 μm diam, thin-walled, without clamps. **Contextual hyphae**: Tramal hyphae of stipe 3–12 μm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 14 μm, with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 15 μm, with smooth and thin wall; ampulliform hyphae rarely; without clamps; gloeoplerous hyphae occasionally, 5–8 μm diam.

Ecology: Found in broad-leaved forests or mixed forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern and central China (Yunnan, Hunan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Nanhua County, Dazhongshan Forestry Farm, in a forest dominated by Fagaceae, altitude 2400 m, 11 October 2021, Jian W. Liu 2574 (MHHNU 11651). HUNAN PROVINCE: Zhangjiajie City, Sangzhi County,

Badagongshan National Nature Reserve, in the mixed forest, altitude 1400 m, 15 September 2020, Zuo H. Chen 32514 (MHHNU 32514).

Commentary: *Ramaria rubrisubtilis*, with its slightly pink branch apices, is visually similar to *R. rubroapicalis*, *R. indoyunnaniana*, *R. botrytoides* and its variants, all of which have pink to red branch apices. They share a close phylogenetic relationship and lack clamps. The main distinguishing feature of *R. rubrisubtilis* is that its pink color is only present at the top 1–2 mm of the apices, and the pink color can easily fade with maturity or environmental influence, finally appearing ivory to pale yellow color. Additionally, *R. rubroapicalis* and *R. indoyunnaniana* have relatively smaller basidiospores sizes (9.76 × 4.63 μm; 7.18 × 4.16 μm; as measured in this study). As *R. botrytoides* is a broadly defined species with its type locality in North America, and *R. rubrisubtilis* has only been found in the central region of China, with basidiospores sizes significantly larger than those documented in the literature, it can be confirmed that the two are not the same species.

48. *Ramaria rubroapicalis* P. Zhang & J. Zhong, **sp. nov.** Fig. 19 q–r and Fig. 75

Mycobank: MB 853378

Etymology: *rubroapicalis* = “*rubr*” + “*apicalis*”, referring to the species having red apices.

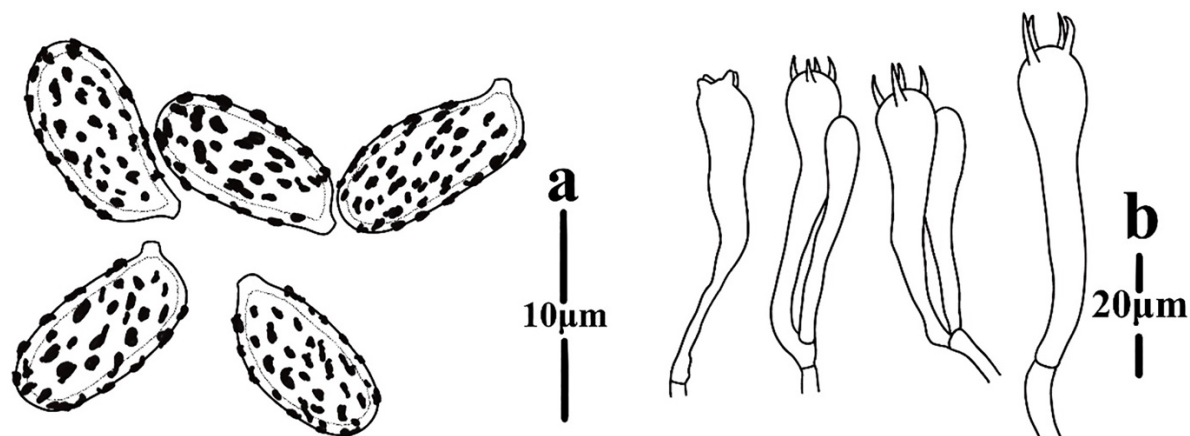


Fig. 75 Microscopic features of *R. rubroapicalis* (MHHNU 11218). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Diagnosis: Apices are pink and retain color without fading easily; stipe is single, with basidiomata obpyramidal in outline; slightly turns to brownish when injured; basidiospores are less than 10 µm in average length, roughened in profile; hyphae and basidia base lack clamps.

Type: CHINA, YUNNAN PROVINCE: Qujing City, Qilin District, near Longyuan Zhumushan Wind Farm, altitude 2250 m, 19 August 2022, P. Zhang 4718 (Holotype, MHHNU 11218, GenBank Acc. No.: ITS = PP467205, nrLSU = PP493523).

Description: *Basidiomata* 8.5 cm high and 8 cm broad, single to fasciculate habit, medium-sized, obpyramidal in outline. *Stipe* 3 × 2 cm, single, fleshy, moderately to large, tapering gradually downward, rounded at base; off-white (1A1) at base, cream (4A3) to pale yellow (2A3) with slightly shell pink (8A3) upward; slightly changing color to brownish yellow (5B3) on bruising; surface smooth; without abortive branches; context of stipe off-white (1A1) when fresh, fibrous to spongy, drying light in weight, easily penetrated. *Branches* in 3–7 ranks, major branches and branches above commonly polychotomous; branches off-white (1A1) to pale yellow (2A3); axils narrowly rounded, mostly V-shaped; internodes diminishing gradually at maturity, lower internodes up to 3 cm; branches commonly 3–8 mm, terete, ascending; context of main branches and upper branches fleshy to gelatinous, off-white (1A1). *Apices* cusped to minutely double-dichotomous, 1–2 mm long, axils near apices 2–8 times, pink (10A3) to light red (10A5). Odor and taste faintly fabaceous.

Basidiospores [30/2/1] (8.3–)8.9–11.0 × (4.0–)4.1–5.2(–5.3) µm, $L_m = 9.76$ µm, $l_m = 4.63$ µm, $Q = (1.80–)1.90–2.34(–2.38)$, $Q_m = 2.11 \pm 0.15$, subcylindrical to narrowly ellipsoid; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 35–55 × 8–12 µm, clavate, without basal clamps; sterigmata 4, 2–8 µm long, incurved or straight, slightly divergent. *Hymenium* unthickening, 55–70 µm. *Subhymenium* extensive, 15–20 µm thick, hyphae, interwoven, 3–6 µm diam, thin-walled, without clamps. *Contextual hyphae:* Tramal hyphae of stipe 3–12 µm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 14 µm, with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 18 µm, with smooth and thin wall; ampulliform hyphae rarely; without clamps; gloeopleurous hyphae occasionally, 7–10 µm diam.

Ecology: In broad-leaved forests. *Basidiomata* occurs in summer and autumn.

Distribution: Known from southwestern and east China (Yunnan, Hunan, Fujian, Zhejiang).

Additional materials examined: CHINA, YUNNAN PROVINCE: Qujing City, Qilin District, near Longyuan Zhumushan Wind Farm, altitude 2160 m, 28 August 2020, Li P. Tang HT277 (MHKMU HT277). Xishuangbanna, Jinghong City, Menglun Town, near the Kino Gurry, in the broad-leaved forest, altitude 900 m, 14 August 2005, P. Zhang 451 (MHHNU 6951); same city, altitude 900 m, 9 July 2006, Jun F. Liang 351 (HKAS 50067), Jun F. Liang 353 (HKAS 50069); HUNAN PROVINCE: Chenzhou City, Rucheng County, Daping Town, Jiulongjiang National Forest Park, in broad-leaved forest, altitude 100 m, 2 October 2020, P. Zhang 4069 (MHHNU 10569); same location, 22 June 2020, P. Zhang 3582 (MHHNU 10352). FUJIAN PROVINCE: Sanming City, Jiangle County, Longqi Mountain National Nature Reserve, 21 August 2023, Nian K. Zeng 8161 (MHHNU 11626). ZHEJIANG PROVINCE,

Lishui City, Qingyuan County, 11 October 2023, P. Zhang 5100 (MHHNU 11600), P. Zhang 5101 (MHHNU 11601).

Commentary: *Ramaria rubroapicalis* have pink apices and white to creamy-colored basidiomata, it resembles to *R. indoyunnaniana* R.H. Petersen & M. Zang found in the southwestern of China. The key difference lies in the smaller basidiospores size of *R. indoyunnaniana* (7.18 × 4.16 µm, as measured in this study).

Ramaria rubroapicalis shares morphological similarities with the globally distributed species *R. botrytoides* (Peck) Corner and its variants. However, the definition of *R. botrytoides* is unclear, described by Corner as a species with short basidiospores (7.0–9.5 × 3.0–3.7 µm, Corner 1950), pinkish apices, gelatinous flesh, common in North America, ranging from salmon-rose colors, and exhibits similar habits to *R. conjunctipes*, basidiospores walls finely rough to nearly smooth, and hyphae with clamps. In Zang Mu and Petersen's articles (Petersen & Zang 1989), *R. botrytoides* is lacks clamps in subgen. *Laeticora*, with abortive branches in stipe, and apices bright yellow.

Considering the comprehensive information, especially the basidiospores size, it becomes evident that *R. rubroapicalis* does not align with the literature's depiction of *R. botrytoides*.

49. *Ramaria sinensis* (R.H. Petersen & M. Zang) P. Zhang & J. Zhong, **stat nov. et comb. nov.** Fig. 19 s–t and Fig. 76

≡ *Ramaria neoformosa* var. *sinensis* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 391 (1989)

Mycobank: MB 855602

Etymology: “*sinensis*” means collected in China.

Diagnosis: *Basidiomata* with a linear stature, featuring small but single stipes that superficially appear fasciculate; lower branches are golden yellow, while upper branches exhibit salmon or orange hues with golden yellow apices; basidia lack clamps; basidiospores are prominently roughened.

Isotype: CHINA, YUNNAN PROVINCE: Dali, Eryuan County, Sanying Town, 27 August 1986, Petersen 47305 (HKAS 20043).

Description: *Basidiomata* 14 cm high and 6 cm broad, linear, elongate obpyriform in outline. *Stipes* up to 1 × 1.5 cm, small, tapered to an acute base, white, smooth, often with abortive branchlets, reluctantly brunnescent on handling; flesh white, solid, moist but not slippery, often mottled hydrophanous; abortive branchlets yellow to pastel orange; surface of stipe and lower branches becoming grey upon drying. *Major branches* several, strictly ascending, terete, clear yellow. *Branches* in 4–7 ranks, terete, strict, orange, pastel orange to pastel salmon, fading in age to “ochraceous buff”; internodes somewhat long throughout, diminishing gradually upward at maturity; axils narrowly rounded below, rounded above; flesh solid, sometimes slippery when cut, orange. *Apices* fine, delicate, knobby-digitate by maturity, somewhat divaricate, golden yellow to pastel orange. Odor negligible; taste negligible or faintly fungoid.

Basidiospores [50/2/2] (11.2–)11.8–15.0 × (4.8–)5.0–5.8(–6.0) µm, $L_m = 13.56$ µm, $l_m = 5.14$ µm, $Q = (2.18–)2.24–2.88(–3.13)$, $Q_m = 2.63 \pm 0.23$, narrowly ellipsoid, conspicuously roughened in profile; wall up to 0.2 µm thick; hilar appendix gradual, prominent, almost perpendicular to basidiospores axis; ornamentation of prominent elongate warts and anastomosing, meandering ridges. *Basidia* 57–65 × 9–11 µm, clavate, without clamps; moderately cyanophilous;

sterigmata 4, short, spindly, straight to curved. *Hymenium* thickening. *Subhymenium* rudimentary; hyphae 1.5–2.5 μm , tightly packed, interwoven, without clamps. *Tramal hyphae of stipe* 4–12 μm wide, hyaline, thick-walled (wall up to 0.5 μm thick), without clamps, tightly interwoven, not agglutinated or adherent; ampulliform swelling rare, not associated with

septa, not unusually thick-walled, with coarse, extensive stalactitiform ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* up to 4–11 μm wide, hyaline, without clamps, thin-walled, parallel, tightly packed, free to locally adherent; ampulliform swellings not observed; gloeoplerous hyphae sometimes common.

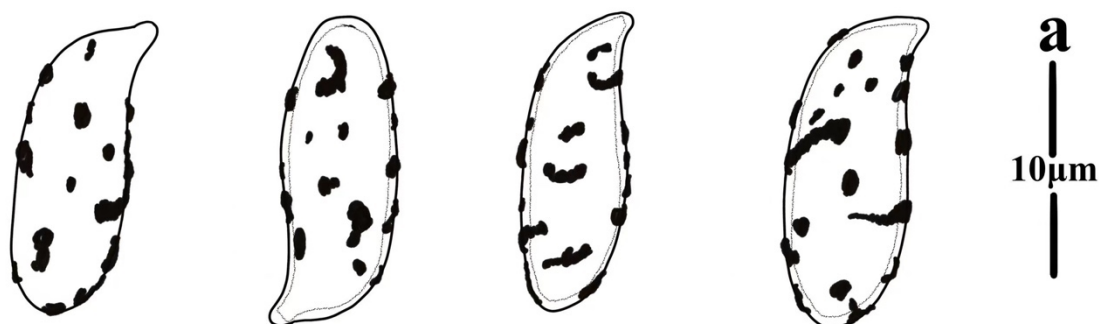


Fig. 76 Basidiospore features of *R. sinensis* (MHHNU 9177). Scale bar: a = 10 μm .

Ecology: In mixed forests dominated by *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known in southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, Yulong County, Laojun Mountain, in a subalpine forest dominated by *Abies*, altitude 3800 m, 14 August 2000, Zhu L. Yang 2920 (HKAS 36620); same city, Tiejia Mountain, in a forest with *Pinus yunnanensis*, altitude 2800 m, 31 July 2001, P. Zhang 79 (MHHNU 6679), P. Zhang 80 (MHHNU 6680); Kunming City, Yiliang County, Zhongdian, Hong Mountain, in *Quercus* and *Pinus* mixed forest, altitude 3700 m, 8 August 2005, Zhu L. Yang 4568 (HKAS 48732); Dali, Dali City, Xianyangfeng, in a mixed forest, altitude 2800 m, 12 August 2018, P. Zhang 3378 (MHHNU 9878). SICHUAN PROVINCE: Ganzi, Kangding City, Pengta Township, altitude 3100 m, 19 August 2017, P. Zhang 2677 (MHHNU 9177).

Commentary: Petersen brought a single fruiting body of this species from the market and identified it as a variant of *R. neoformosa*. Within the species, two varieties have been described, basidiospores of *R. neoformosa* var. *neoformosa*

are (10.7–11.8 $\times$ 4.8–5.6 μm , L_m = 10.9 μm , l_m = 2.09 μm ; Petersen 1976), *R. neoformosa* var. *macrospora* Pet. known only from eastern Canada and with basidiospores (11.2–14.8 $\times$ 3.6–4.3 μm , L_m = 12.57 μm , l_m = 3.01 μm ; Petersen 1986). Our basidiospores measurements of *R. sinensis* slightly exceeded those reported by Petersen, with slightly larger and wider basidiospores. However, the bright pink flesh of branches and our phylogenetic analyses significant its identification as *R. neoformosa* var. *sinensis* ($\equiv$ *R. sinensis*).

50. *Ramaria subgelatiniaurantia* P. Zhang & J. Zhong, **sp. nov.** Fig. 19 u–v and Fig. 77

Mycobank: 853033

Etymology: The prefix “sub-” indicates “similarity”. The species epithet “*subgelatiniaurantia*” suggests that this species is similar to *R. gelatiniaurantia*, sharing features such as gelatinous flesh and an orange color of the basidiomata.

Diagnosis: Basidiomata are orange-yellow in color, with apices concolorous with branches; stipe is short, stout, gelatinous, with abortive branches; does not change color when injured; hyphae and basidia base lack clamps.

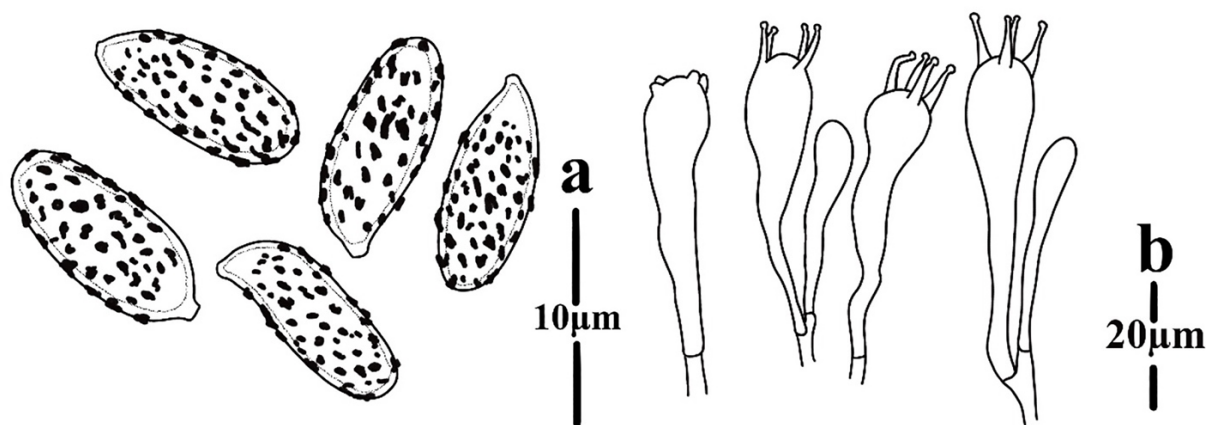


Fig. 77 Microscopic features of *R. subgelatiniaurantia* (MHHNU 10859). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4359 (Holotype, MHHNU 10859, GenBank Acc. No.: ITS = PP467201, nrLSU = PP493520).

Description: *Basidiomata* 9 cm high and 9 cm broad, single, usually obtriangular in outline. *Stipe* 2.5–2 cm, single, stout and short, tapering downward evenly to rounded base; off-white (1A1) to pastel yellow (2A4); not changing color on bruising; surface smooth; with abortive branches; context of stipe off-white (1A1) when fresh, drying light in weight, easily penetrated, gelatinous, firm. *Branches* in 3–5 ranks, major branches and lower branches commonly polychotomous; branches pale yellow (2A3) to yellowish orange (4A8); axils narrowly rounded, mostly V-shaped; internodes diminishing gradually at maturity, lower internodes to 4 cm; branches commonly 2–25 mm, terete, ascending; context of main branches and upper branches semi-gelatinous, off-white (1A1). *Apices* broadly rounded, 2–6 mm long, polychotomous, concolorous with branches. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2] (9.0–)9.4–12.0(–12.4) × (3.4–)3.7–5.0(–5.4) μm , $L_m = 10.67 \mu\text{m}$, $l_m = 4.47 \mu\text{m}$, $Q = (1.99\text{--}2.10\text{--}2.98\text{--}3.18)$, $Q_m = 2.51 \pm 0.26$, subcylindrical to narrowly ellipsoid; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 46–72 × 7–12 μm , clavate, without basal clamps; sterigmata 4, 4–6 μm long, incurved or straight, slightly divergent. *Hymenium* unthickening, 60–75 μm . *Subhymenium* extensive, 20–40 μm thick, hyphae, interwoven, 3–6 μm diam, thin-walled, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 3–12 μm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 14 μm , with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 15 μm , with smooth and thin wall; ampulliform hyphae rarely; without clamps; gloeoplerous hyphae commonly, 4–8 μm diam.

Ecology: Found in mixed forests dominated by *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Sichuan).

Additional material examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4358 (MHHNU 10858).

Commentary: *Ramaria subgelatiniaurantia* has only been collected in the southwestern of China until now. In fact, characterized by gelatinous stipes, orange-yellow colored basidiomata, and lack of clamps is a widespread complex group species, found in North America, Asia, and Europe. In Franche's work, he identified a species closely related to *R. subgelatiniaurantia* as *R. primulina*.

Ramaria primulina, reported by Petersen in 1986 with its type locality in Canada, has also been observed by Franche in Europe, particularly in Spain, Italy, Finland, and Norway. Franche (2021) described the European specimens as having pale yellow color, U-shaped axils, gelatinous context hyphae, and basidiospores measuring 8.2–11.2 × 3.5–5.2 μm , occasionally with clamps, growing in coniferous forests. However, Petersen described *R. primulina* with fibrous stipes and have clamps, leading to the suggestion that Franche's identification of *R. primulina* might not be the same species Petersen described. Franche's observations showing slightly smaller basidiospores on the type specimen compared to Petersen's description. Differences in basidiomata color and basidiospores size, combined with the results of our two-gene phylogenetic analysis, confirm that *R. subgelatiniaurantia* is not the same as Franche's, but aligns with the complex reported by Marr in 1973, including *R. gelatiniaurantia* and its variants.

The complex of *R. gelatiniaurantia* and its variants includes *R. gelatiniaurantia*, *R. hilaris* var. *olympiana*, *R. flavigelatinosa*, and *R. verlotensis*. In this complex, *R. flavigelatinosa* and *R. hilaris* var. *olympiana* have yellow branch flesh, while *R. verlotensis* has a pale orange basidiomata, wide cauliflower-shaped basidiomata with an overall yellow-pink hue. These characteristics confirm that *R. subgelatiniaurantia* does not belong to the complex described above.

51. ***Ramaria subthindii*** P. Zhang & J. Zhong, **sp. nov.** Fig. 19 w–x and Fig. 78

Mycobank: MB 853373

Etymology: The specific epithet "*subthindii*" means that the species is similar to *R. thindii*.

Diagnosis: Basidiomata are small to medium sized and pale yellow; stipe is short, stout, gelatinous, and smooth; hyphae and basidia base lack clamps; average basidiospores length exceeds 10 μm .

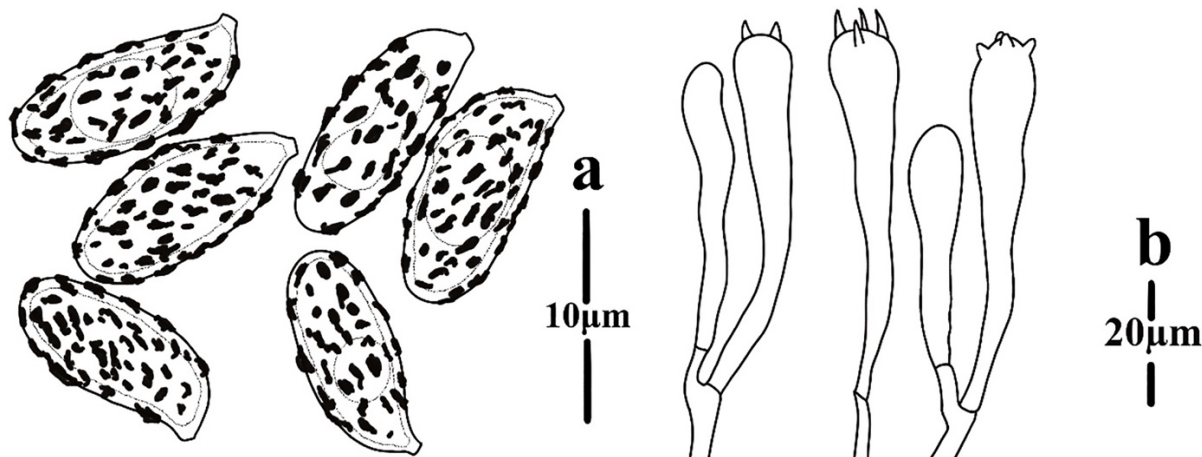


Fig. 78 Microscopic features of *R. subthindii* (MHHNU 9131). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Type: CHINA YUNNAN PROVINCE: Pu'er City, Lancang County, Menglang Town, altitude 980 m, brought in mushroom market, 30 July 2017, P. Zhang 2631 (Holotype, MHHNU 9131, GenBank Acc. No.: ITS = PP467187, nrLSU = PP493507, *tef1-a* = PP480389).

Description: *Basidiomata* 6–8 × 6–7 cm, fasciculate habit, usually obpyriforme to broadly fusiform in outline. *Stipes* up to 1.5–3 × 2–3 cm, single to compound, tapering gradually downward; milk white (1A2) at base, milk white (1A2) to pale yellow (2A3) upward; surface smooth; with abortive branches; some region changing color to brownish gray (6E2) on bruising or purple spots caused by soil particles; context of stipe off-white (1A1) to jelly-like pastel yellow (2A4) when fresh, drying light in weight, easily penetrated, gelatinous, hard. *Major branches* several, ascending, terete. *Branches* in 3–5 ranks, major branches and lower branches commonly dichotomous; branches pale yellow (2A3) to chicken yellow (2A6); axils broadly rounded, mostly U-shaped; internodes all short; branches terete, sparsely, subparallel upward; context of main branches and upper branches gelatinous, viscid, brittle, pastel yellow (2A4). *Apices* broadly rounded, molar-like when young, terraced, short-digitate at maturity, concolorous with branches or slightly pale yellow (2A3) to chicken yellow (2A6). Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [50/2/2] (8.5–)9.0–12.6(–13.9) × 4.0–5.4(–5.6) μm , $L_m = 10.87 \mu\text{m}$, $l_m = 4.91 \mu\text{m}$, $Q = (-1.99)2.00-2.71(-2.84)$, $Q_m = 2.34 \pm 0.23$, ellipsoid, noticeably rough; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 45–65 × 8–11 μm , clavate, without basal clamps; sterigmata 4, 3–6 μm long, short and straight, somewhat scattered. *Hymenium* unthickening, 50–70 μm . *Subhymenium* extensive, hyphae, interwoven, 1–3 μm diam, adherent, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 3–10 μm wide, hyaline, tightly interwoven, heavily agglutinated, ampulliform inflations occasionally; tramal hyphae of branches central hyphae slightly narrow, 2–10 μm , hyaline, thin-walled, agglutinated, strictly parallel, tightly packed, ampulliform inflations rare; gloeoplerous hyphae commonly, 4–8 μm diam.

Ecology: Solitary or gregarious on soil in mixed forests dominated by Fagaceae and Pinaceae. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional material examined: CHINA YUNNAN PROVINCE: Pu'er City, Ning'er Hani and Yi Autonomous County, 1 September 2008, B. Feng 276 (HKAS 55387).

Commentary: The Chinese species *R. subthindii* shares a close morphological affinity with the type collection of *Ramaria thindii* from India, both characterized by yellow basidiomata, gelatinous flesh, and absence of clamps. However, *R. subthindii* has a nearly 1:1 ratio of length to width in its basidiomata, a short and stout stipe, internodal all short, and an overall yellowish-white coloration without orange hues in the basidiomata. In contrast, *R. thindii* has more linear basidiomata, slenderer stipe, and mature basidiomata with orange or pink hues, along with slightly smaller basidiospores.

Moreover, *R. subthindii* is easily confused with *R. hunanensis* from Hunan, China. Macroscopically, they are indistinguishable in the field, and under the microscope, their basidiospores sizes are quite similar. However, *R. hunanensis* is currently known only from Hunan, while *R. subthindii* is distributed in the southwestern China. Our two-gene phylogenetic analysis also indicates a close phylogenetic relationship between the two, confirming them as distinct but closely related species within the *Ramaria*. *Ramadia verlotenses* Marr & D.E. Stuntz (1974) was recovered as phylogenetically closely related to *R. subthindii*. The two species share similar basidiospore dimensions (with *R. verlotenses* measuring 10.1 × 4.9 μm) but differ in basidiomata coloration: *R. subthindii* is pale yellow to chicken yellow, whereas *R. verlotenses* exhibits pallid salmon to salmon-colored basidiomata.

Ramaria* ser. *Hemirubellae P. Zhang & J. Zhong, **ser. nov.**
Mycobank: MB 852712

Etymology: “*hemi*” means “half” or “semi”, “*rubella*” means “reddish” or “red”, is proposed because the collections of the series are pale reddish.

Type species: *R. hemirubella* R.H. Petersen & M. Zang, Acta bot. Yunn. 8(3): 285, 1986.

Diagnosis: basidiomata are milk white to pale yellow, with apices concolorous with branches or pale red; Darkens to brunnescent or rubric-brunnescent when injured; basidia base and hyphae exhibit clamps; basidiospores are ornamented with conspicuous longitudinal striae.

Commentary: This series has collected four species in China. Additionally, another taxon within this series is characterized by a yellow basidiomata, known as *R. flavissima* Schild (= *R. pallidissima* Schild & G. Ricci).

52. ***Ramaria eryuanensis*** R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 364, 1989. Fig. 20 a–b and Fig. 79

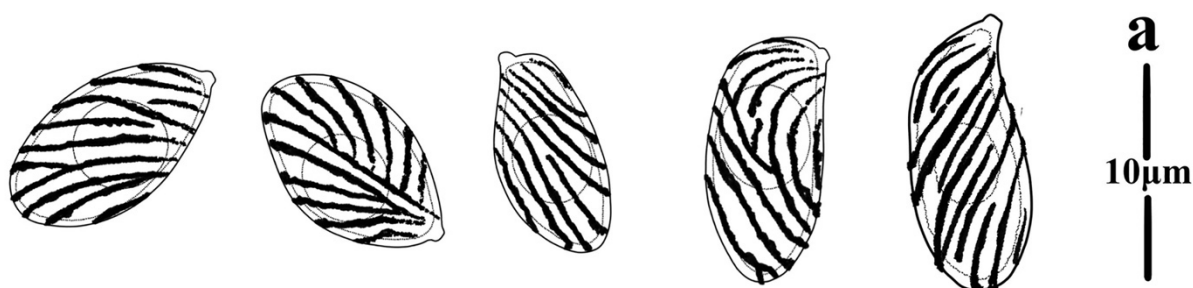


Fig. 79 Basidiospores of *R. eryuanensis* (MHHNU 10837). Scale bar: a = 10 μm .

Description: *Basidiomata* 12 cm high and 8 cm broad. *Stipe* 7 × 5 cm, massive, rounded at base, sometimes rooting, smooth, somewhat flattened, often with a few abortive stumps high on stipe, somewhat flattened laterally, white at base, sometime suffused pinkish at base, off-white above, easily brunnescent on all surfaces where handled or rubbed, flesh white, solid, not gelatinous or slippery, sometimes slowly sordid grey where cut. Major branches 2–4, stout, short, more or less terete, off-white (pale ochraceous buff, pale pinkish cinnamon). Branches in 3–5 ranks, short, elongating reluctantly, crowded, more or less terete, pallid rose-beige (pinkish buff), easily brunnescent; flesh off-white, fibrous; internodes short, hardly diminishing above; axils narrowly rounded throughout. Apices digitate to awl-shaped, long, crowded, pastel rose-tan (light pinkish cinnamon, light ochraceous cinnamon), easily brunnescent. Odor faintly; taste negligible to faintly fabaceous.

Basidiospores [132/5/5](9.5–)10.7–13.1(–14.2) × (4.0–)4.2–6.0(–7.0) µm, $L_m = 11.74$ µm, $l_m = 4.94$ µm, $Q = (1.57–)1.98–2.80(–3.07)$, $Q_m = 2.39 \pm 0.29$, subboletoid to narrowly ellipsoid, smooth in profile; wall up to 0.2 µm thick; hilar appendix prominent, with a throat; ornamentation of coarse striae, arranged in abaxial-distal to adaxial-proximal orientation. *Subhymenium* extensive, hyphal. *Hymenium* thickening. *Tramal hyphae* of stipe 3–11 µm wide, hyaline, clamped, thin to thick-walled (wall up to 1 µm thick), freely branched, interwoven, not agglutinated or adherent; ampulliform inflations as clamps or asymmetrical, not unusually thick-walled, with extensive stalactitiform ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae* of upper branches 2–8 µm diam, hyaline, thick-walled (wall up to 1 µm thick), straight, occasionally branched, parallel, not agglutinated or adherent; ampulliform clamps up to 15 µm broad, not unusually thick-walled, asymmetrical, unornamented; gloeoplerous hyphae not observed.

Ecology: In broad-leaved or coniferous forest; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3415 (MHHNU 9915); Lijiang City, brought from Lijiang mushroom market, 2 September 1986, Petersen 47306 (isotype, HKAS 20044); same city, Yulong County, Yulong Snow Mountain, altitude 3700 m, 27 July 2017, P. Zhang 2800

(MHHNU 9300); same city, Tuanshan Reservoir, altitude 2500 m, Li P. Tang 361 (HKAS54592); Kunming City, bought from mushroom market, 23 July 2017, P. Zhang 2601 (MHHNU 9101); Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 2 August 2001, P. Zhang 94 (MHHNU 6594); same city, Nanhua County, Dazhongshan Forestry Farm, in mixed broadleaf-coniferous forest, altitude 2218 m, 9 August 2017, Jian W. Liu 787(MHHNU 11640). SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4336 (MHHNU 10836), P. Zhang 4338 (MHHNU 10838); same city, Sewulong Village, within a *Quercus* forests, altitude 3700 m, 3 September 2018, P. Zhang 3595 (MHHNU 10095); same location, 26 August 2017, P. Zhang 2776 (MHHNU 9276).

Commentary: *Ramaria eryuanensis* exhibits light pinkish cinnamon to light ochraceous cinnamon apices. According to the literature (Petersen, & Zang 1989), Kunming Institute of Botany holds two isotype specimens of *R. eryuanensis*: HKAS 20042 and HKAS 20044, with HKAS 20042 being designated as the isotype for *R. eryuanensis*. Upon examination of these specimens, we discovered that HKAS 20042 exhibits basidiospores dimensions of 14.5–17.0 × 4.5–6.5 µm, which are notably inconsistent with the literature. Consequently, it may be unsuitable for HKAS 20042 to continue as the isotype for *R. eryuanensis*. HKAS 20044, on the other hand, aligns with the characteristics detailed in the literature. However, this specimen is also as the isotype for *R. linearioides*, a species that owns verruculose basidiospores. Thus, it cannot be considered the isotype for *R. linearioides*.

53. *Ramaria delicorosea* P. Zhang & J. Zhong, **sp. nov.** Fig. 20 c–d and Fig. 80

Mycobank: MB 853006

Etymology: *delicorosea* = *delico* + *rosea*, proposed because this species has rose-pink colored apices of basidiomata and is considered delicious.

Diagnosis: basidiomata are off-white to cream color, with apices and young branches ranging from pink to red purple; color change upon handling is minimal, with a slow and slight transition to pale brown; basidiospores are ornamented with longitudinal stria; hyphae and basidia base exhibit clamps.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Mouding County, Huafo Mountain, altitude 2400 m, 23 August 2018, Zuo H. Chen 31322 (Holotype, MHHNU 31322, GenBank Acc. No.: ITS = PP4671107, nrLSU = PP493439).

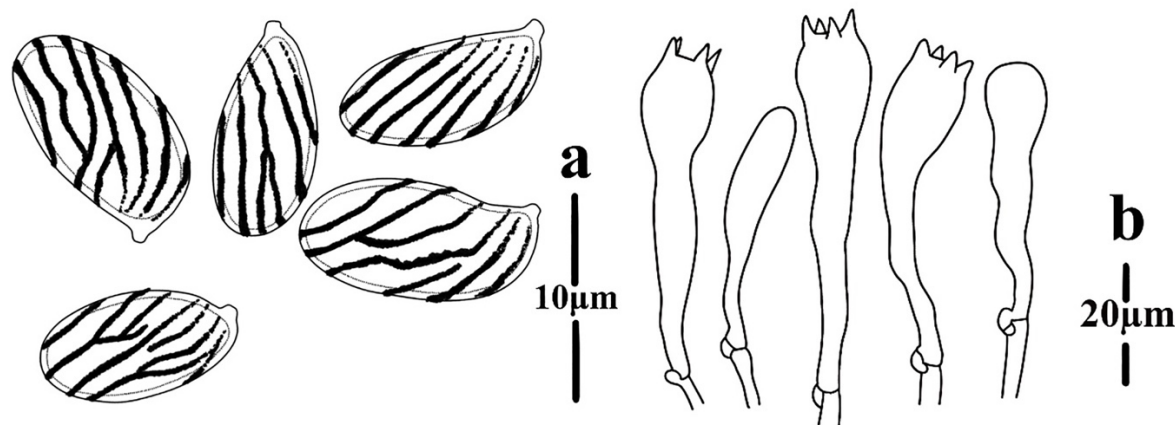


Fig. 80 Microscopic features of *R. delicorosea* (MHHNU 31322). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 10 cm high and 10 cm broad, medium sized. *Stipe* 2 × 1 cm, single, falsely fasciculate, compound-connate, abortive branchlets occasional, off-white (1A1) to cream (4A3); nearly not changing color or slowly and slightly changing color to grayish yellow (2B5) when handle; flesh solid, off-white (1A1), flesh to fibrous, drying soft, easily penetrated. *Major branches* several, compound at base. *Branches* in 2–5 ranks, short and crowded; cream (4A3) to purplish red (14A8); axils narrowly rounded; internodes diminishing gradually at maturity. *Apices* acute, crowded, rose (12A4) to purplish red (14A8). Odor weakly fragrant; taste negligible.

Basidiospores [60/2/2] 10.0–12.0(–13.0) × 4.0–6.0(–7.0) μm , $L_m = 11.14 \mu\text{m}$, $l_m = 5.43 \mu\text{m}$, $Q = (1.57)–1.83–2.75(–2.88)$, $Q_m = 2.29 \pm 0.23$, long-ellipsoid, conspicuously striae in profile, strongly cyanophilous; *Basidia* 45–65 × 7–13 μm , clavate, clamped at base; sterigmata mostly 4, 3–6 μm , stout and straight. *Subhymenium* rudimentary, hyphal. *Hymenium* unthickening. *Tramal hyphae* of *stipe* 6–14 μm wide, hyaline, conspicuously clamped, thin to thick-walled, interwoven, not agglutinated or adherent; ampulliform clamps up to 18 μm broad, usually not thick-walled; gloeoplerous hyphae not observed. *Tramal hyphae* of *upper branches* up to slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated or adherent, parallel and hardly branched inward; ampulliform clamps occasional; gloeoplerous hyphae not observed.

Ecology: Found in broad-leaved or forests or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Shuangbai County, 22 August 2018,

Zuo H. Chen 31297 (MHHNU 31297); Nanhua County, bought from mushroom market, 9 August 2016, P. Zhang 2379 (MHHNU 8879), P. Zhang 2380 (MHHNU 8880), P. Zhang 2381 (MHHNU 8881), P. Zhang 2382 (MHHNU 8882), P. Zhang 2383 (MHHNU 8883), P. Zhang 2385 (MHHNU 8885).

Commentary: This species was only collected in Chuxiong, Yunnan, and is very similar to *R. linkongshanensis* L. Fan, Ying Li & N. Mao [11–13(–15) × 4.5–5 μm , $Q = (2.2)–2.4–2.7$, $Q_m = 2.53 \pm 0.16$, Li et al. 2024; 12.97 × 4.73 μm , as measured in this study]. A subtle difference is that the basidiospores of this species are slightly smaller, and the apices of the branches exhibit a pink coloration that does not easily fade.

54. *Ramaria hemirubella* R.H. Petersen & M. Zang, Acta bot. Yunn. 8(3): 285, 1986. Fig. 20 e–f and Fig. 81

Description: *Basidiomata* 14 cm high and 8 cm broad, broadly fusiform to obpyriforme in outline. *Stipe* 5 × 3 cm, single, falsely fasciculate, to compound-connate, smooth, with a few abortive branchlets, off-white with a hint of pink upward, in age fleshly buff, slowly easily brown to red-brown where handled or chaffed, sometimes staining lemon yellow where handled; flesh solid, off-white, in age suffused flesh color, moist but not gelatinous or slippery, drying soft, light in weight, easily penetrated. *Major branches* several, more or less terete, ascending. *Branches* in 3–7 ranks, linear ascending, of two types: 1) typical, terete, pallid ochre, sometimes with hint of flesh upward; internodes diminishing gradually upward; *Apices* short digitate, suffused rose-pink in apical centimeter, deep red apically tan in age; and 2) grossly inflated, longitudinally rugulose, ruddy. Odor weakly fragrant; taste negligible.

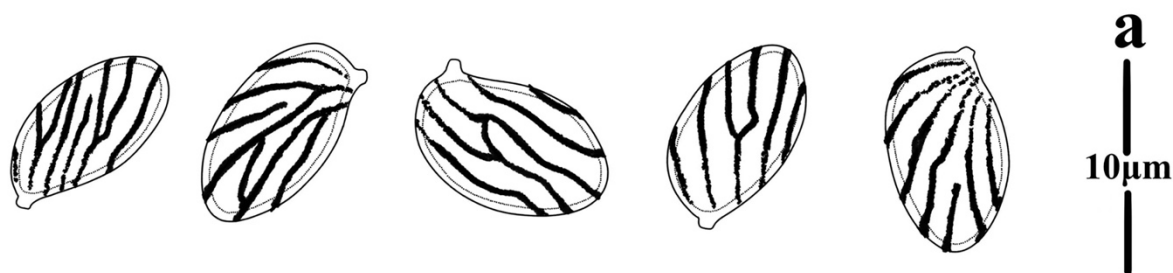


Fig. 81 Basidiospores of *R. hemirubella* (MHHNU 31267). Scale bar: a = 10 μm .

Basidiospores [50/2/2] (8.0–)8.5–11.0 × (3.0–)4.0–5.5 μm , $L_m = 9.47 \mu\text{m}$, $l_m = 4.94 \mu\text{m}$, $Q = (1.78)–1.80–2.26(–3.33)$, $Q_m = 2.07 \pm 0.29$, ellipsoid, smooth to very obscurely undulate in profile; wall up to 0.2 μm thick; hilar appendix prominent, with pronounced throat; ornamentation of conspicuous to broken striae. *Basidia* 68–75 × 8–9 μm , clavate, clamped; weakly cyanophilous; sterigmata (2–) 4, slender, long, straight. *Subhymenium* rudimentary. *Hymenium* thickening. *Tramal hyphae* of *stipe* 4–12 μm wide, hyaline, conspicuously clamped, thin to thick-walled (wall up to 0.5 μm thick), easily broken, interwoven, not agglutinated or adherent; ampulliform clamps up to 15 μm broad, thick-walled (wall up to 1 μm thick), with conspicuous stalactiform ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae* of *upper branches* up to 4–18 μm wide, hyaline, thick-walled (wall up to 1 μm locally), conspicuously clamped, not agglutinated or

adherent, parallel and hardly branched inward, with cells cigar to barrel-shaped, outward more interwoven, gnarled, freely branched; ampulliform clamps common, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed.

Ecology: Found in broad-leaved or forests or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Pu'er City, Simao District, 20 September 1983, Petersen 45673 (HKAS 10419); same place, 10 August 2001, altitude 1300 m, Zhu L. Yang 3181 (HKAS 38358); same location, 11 August 2001, altitude 1600 m, Zhu L. Yang 3183 (HKAS 38360); same city, Menglang Town, in a forest dominated by Pinaceae, altitude 980 m, 30 July 2017, P. Zhang 2630 (MHHNU 9130); Kunming, bought from Ciba

mushroom Market, 2 August 2008, P. Zhang 702 (MHHNU 7202); Chuxiong, Nanhua County, Yulu Township, Sapiwu Village, with broad-leaved, coniferous or mixed forests, altitude 2000 m, 22 August 2018, Zuo H. Chen 31267 (MHHNU 31267).

Commentary: The isotype of this species (HKAS 10420) was found to have mold growth. Petersen first described *R. hemirubella* from a single specimen obtained at a mushroom market located in south-central Yunnan (Petersen & Zang 1986, 1989). Based on these additional collections, we can provide color notes and confirm that the apices are naturally deep red, not strained or secondarily suffused. Moreover, the branches constituted only a portion of one basidiomata, while the rest exhibited typical branches and apices.

Wu (1987) may classify this species as *R. botrytis* var. *holorubella* (Atk.) Corner. Petersen examined the type specimens of *Clavaria holorubella* and found the basidiospores to measure $12\text{--}15.6 \times 3.5\text{--}5.0 \mu\text{m}$. Wu reported measurements of Chinese material as $9.2\text{--}13 \times 3\text{--}5.0 \mu\text{m}$, which are closer to those of *R. hemirubella*. One collection (no. 47285) produced basidiospores substantially longer than those of others ($10.8\text{--}13.7 \times 3.6\text{--}4.7 \mu\text{m}$, $Q = 2.50\text{--}3.17$, $Q_m =$

2.82 ; $L_m = 12.26 \mu\text{m}$). Basidia of these basidiomata were predominantly 2-sterigmate, which may account for the larger basidiospores size. Although longer than those of other collections of *R. hemirubella*, they were still considered shorter than those of *R. holorubella*, and Petersen found little reason to emphasize the collection further.

55. *Ramaria linkongshanensis* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 23 (2024) Fig. 20 g–h and Fig. 82

Description: *Basidiomata* 10 cm high and 10 cm broad. *Stipe* 4×3 cm, single, falsely fasciculate, compound-connate, abortive branchlets occasional, off-white to cream; nearly not changing color or slowly and slightly changing color to grayish yellow when handle; flesh solid, off-white, flesh to fibrous, drying soft, easily penetrated. *Major branches* several, compound at base. *Branches* in 2–5 ranks, short and crowded; cream to rose; axils narrowly rounded; internodes diminishing gradually at maturity. *Apices* acute, crowded, rose to pink. Odor weakly fragrant; taste negligible.

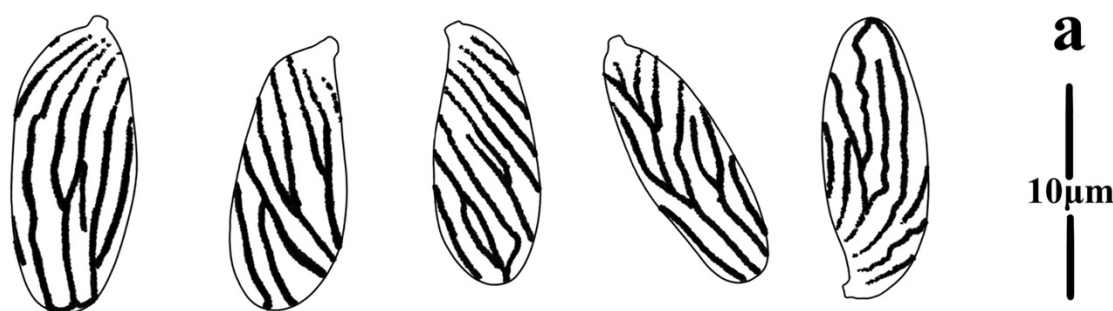


Fig. 82 Basidiospore features of *R. linkongshanensis* (MHHNU 9873). Scale bar: a = 10 μm .

Basidiospores $[60/2/2](11.4\text{--}11.9\text{--}14.0\text{--}14.3) \times (3.9\text{--}4.0\text{--}5.0\text{--}5.8) \mu\text{m}$, $L_m = 12.97 \mu\text{m}$, $l_m = 4.73 \mu\text{m}$, $Q = (2.34\text{--}2.40\text{--}3.42\text{--}3.50)$, $Q_m = 2.83 \pm 0.31$, long-ellipsoid, conspicuously striae in profile, strongly cyanophilous; *Basidia* $35\text{--}60 \times 6\text{--}10 \mu\text{m}$, clavate, clamped at base; sterigmata mostly 4, 3–6 μm , stout and straight. *Subhymenium* rudimentary, hyphal. *Hymenium* unthickening. *Tramal hyphae* of stipe 6–14 μm wide, hyaline, conspicuously clamped, thin to thick-walled, interwoven, not agglutinated or adherent; ampulliform clamps up to 18 μm broad, usually not thick-walled; gloeoplerous hyphae not observed. *Tramal hyphae* of upper branches up to slightly narrowly, hyaline, thin walled, conspicuously clamped, not agglutinated or adherent, parallel and hardly branched inward; ampulliform clamps occasional; gloeoplerous hyphae not observed.

Ecology: Found in broad-leaved or forests or coniferous forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern and north China (Yunnan, Shanxi).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved forest, altitude 2350 m, 21 August 2022, P. Zhang 4737 (MHHNU 11237); same location, altitude 2400 m, 23 August 2023, P. Zhang 5030 (MHHNU 11530); same location, 27 July 2021, Zuo H. Chen 32922 (MHHNU 32933);

Dali, Dali City, Xianyangfeng, in a mixed forest, altitude 2800 m, 12 August 2018, P. Zhang 3373 (MHHNU 9873), P. Zhang 3374 (MHHNU 9874), P. Zhang 3383 (MHHNU 9883); Kunming, bought from mushroom market, 29 September 2006, P. Zhang 574 (MHHNU 7074).

Commentary: Most species of *Ramaria* in ser. *Hemirubellae* are characterized by pink apices. However, *R. linkongshanensis* is particularly notable within this series, not only for its pink apices but also for possessing the largest basidiospore, making it a distinctive species among them.

Ramaria ser. *Laetae* P. Zhang & J. Zhong, ser. nov.

Mycobank: MB 852734

Diagnosis: Differs from other series by its large basidiomata, dense branching, and yellow to bright orange coloration.

Type species: *R. laeta* P. Zhang & J. Zhong.

Description: 1) basidiomata pale orange to bright orange, big sized; 2) apices, branches and stipe concolorous with each other; 3) changing color to purple-brown on bruising or hurt; 4) branches and apices crowded; 5) basidia base and hyphae clamps or without clamps.

Commentary: This series includes five species collected exclusively in China. The basidiomata of these species range from yellow to orange, with or without clamps.

56. *Ramaria aurantiapicalis* P. Zhang & J. Zhong, **sp. nov.** Fig. 21 a–b and Fig. 83

Mycobank: MB 853249

Etymology: *aurantiapicalis* = *aurantia* + *apicalis*, referring to the yellow to orange color of the basidiomata with apices that turn brown when injured.

Diagnosis: Basidiomata exhibits a salmon to orange tone,

with apices are yellow to orange and crowded, turning dark brown when injured. Basidia base and hyphae lack clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Sewulong Village, within a *Picea* forest, altitude 3450 m, 5 September 2018, P. Zhang 3599 (Holotype, MHHNU 10099, GenBank Acc. No.: ITS = PP467237).

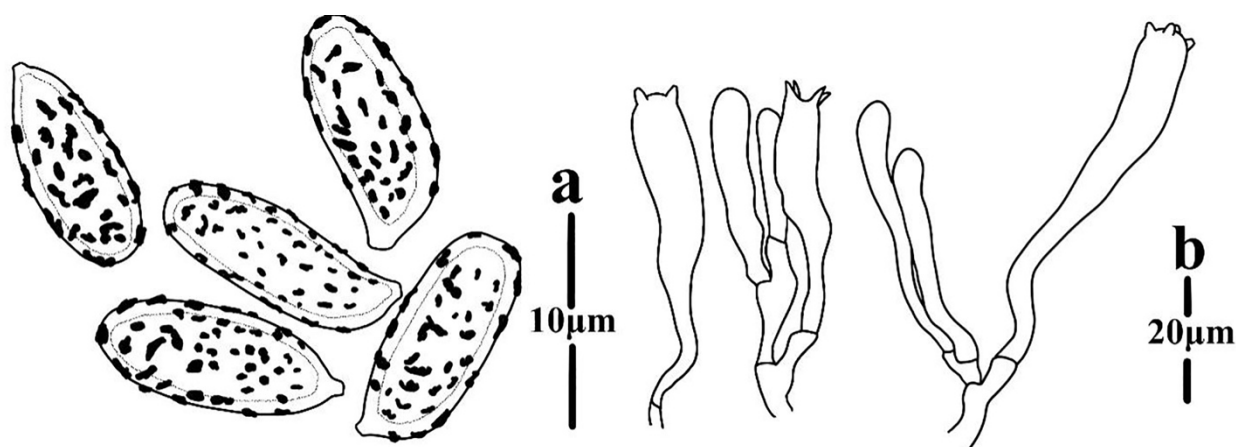


Fig. 83 Microscopic features of *R. aurantiapicalis* (MHHNU 10099). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Description: Basidiomata 9 cm high and 11 cm broad, obtriangular to subcircular in outline. Stipe 4 × 3 cm, single to falsely fasciculate, tapering to narrowly rounded base, pruinose at base, longitudinally gnarled or rugose, with abortive branchlets, brunnescent when injury. flesh off-white (1A1), moist but not gelatinous or slippery. Major branches several, terete, off-white (1A1) at base, cream (4A3) to salmon (6A4) upward. Branches in 3–6 ranks, ascending, terete, salmon (6A4) to apricot yellow (5B6); flesh more pallid, brittle to brittle-fibrous; internodes diminishing gradually at maturity; axils narrowly rounded throughout. Apices short and crowded, double-dichotomous, yellowish orange (4A8) color, turned brown (6E8) when hurt. Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (9.1–)9.4–11.6(–12.4) × (3.5–)3.7–5.1(–5.4) μm, $L_m = 10.26$ μm, $l_m = 4.28$ μm, $Q = (1.97)–2.10–2.83(–2.99)$, $Q_m = 2.45 \pm 0.23$, subcylindrical to ellipsoid, slightly roughened in profile; hilar not prominent; ornamentation of small, randomly scattered flat warts. **Basidia** 40–60 × 6–9 μm, clavate, without clamps; sterigmata 4, very slender, straight. **Subhymenium** extensive, pseudo-parenchymatous. **Hymenium** thickening. **Tramal hyphae of stipe** 4–13 μm wide, hyaline, without clamped, tightly interwoven, not agglutinated or adherent; ampulliform clamps up to 12 μm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** up to 5–11 μm wide, hyaline, thin walled, without clamps, strictly parallel, more inflated inward, tightly packed, not agglutinated to adherent; ampulliform clamps up to 13 μm broad, gloeoplerous hyphae not observed.

Ecology: In *Picea* forests or broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Deqin County, Baima Snow Mountain Nature Reserve, in *Picea* forest, altitude 3750 m, 17 August 2018, P.

Zhang 3443 (MHHNU 9943). SICHUAN PROVINCE: Ganzi, Kangding City, Sewulong Village, within a *Picea* forest, altitude 3450 m, 5 September 2018, P. Zhang 3600 (MHHNU 10100); same city, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4366 (MHHNU 10866).

Commentary: *Ramaria aurantiapicalis* is similar to *R. robustiflava* and *R. laeta* in that they share salmon or yellow basidiomata and have similar-sized basidiospores. However, *R. aurantiapicalis* differs in that it develops dark brown apices when injured and lacks clamps, whereas the latter two species possess clamps.

57. *Ramaria cadmioaurantiaca* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 16 (2024)

Original description in Li et al. (2024).

58. *Ramaria laeta* (R.H. Petersen & M. Zang) P. Zhang & J. Zhong, **stat nov. et comb. nov.** Fig. 21 c–d and Fig. 84

≡ *Ramaria rubricarnata* var. *laeta* R.H. Petersen, in Petersen & Zang, Acta bot. Yunn. 11(4): 394 (1989)

Mycobank: MB 853237

Etymology: “*laeta*”, referring to the bright orange color of the basidiomata.

Diagnosis: Basidiomata are salmon to orange in tone and large-sized; apices are broadly acute and concolorous with branches; color changes to vivescent upon bruising or injury; branches and apices are crowded; basidia base and hyphae have clamp connection.

Isotype: CHINA, YUNNAN PROVINCE: Dali, Eryuan County, Sanying Township, brought from mushroom market, 27 August 1986, Petersen 47292.

Description: Basidiomata 14 cm high and 10 cm broad, obovate in outline. Stipe 6 × 4 cm, single to falsely fasciculate, stout, with abortive branchlets, minutely pruinose between substrate particles and between stipes, off-white, somewhat rugulose, brunnescent at base; flesh off-white, moist but not

gelatinous or slippery. *Major branches* 3–5, flattened or terete, crowded, brunnescent where handled, concolorous with stipe downward, salmon to orange upward. *Branches* in 3–5 ranks, ascending, terete, salmon to salmon-orange; flesh more pallid, brittle to brittle-fibrous; internodes diminishing

gradually at maturity; axils rounded throughout. *Apices* short and narrowly rounded, double-dichotomous, crowded, yellowish, minutely short digitate when mature, concolorous with branches. Odor and taste faintly fabaceous.

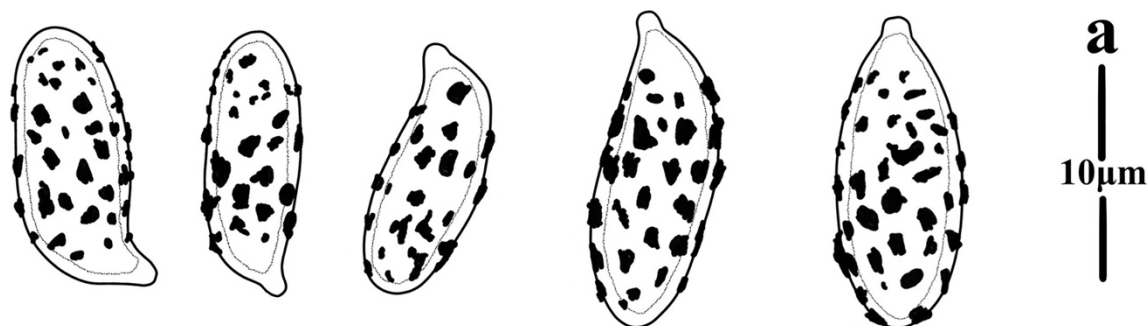


Fig. 84 Basidiospore features of *R. laeta* (MHHNU 33922). Scale bar: a = 10 μm.

Basidiospores [50/2/2] (8.8–)9.3–12.6(–13.0) × (3.8–)3.9–5.0(–5.2) μm, $L_m = 10.66$ μm, $l_m = 4.33$ μm, $Q = (1.92\text{--})2.05\text{--}2.75(–2.89)$, $Q_m = 2.46 \pm 0.22$, ellipsoid to subcylindrical, flattened adaxially, roughened in profile; wall up to 0.2 μm thick; hilar prominent; ornamentation of plat-like wart and small warts randomly scattered. **Basidia** 40–60 × 6–9 μm, clavate, clamped; sterigmata 4, very slender, straight. **Subhymenium** extensive, pseudo-parenchymatous. **Hymenium** thickening. **Tramal hyphae of stipe** 4–12 μm wide, hyaline, conspicuously clamped, parallel, not agglutinated or adherent; ampulliform clamps up to 14 μm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** up to 5–10 μm wide, hyaline, conspicuously clamped, thin-walled, parallel, not agglutinated to adherent; ampulliform clamps and gloeoplerous hyphae not observed.

Ecology: In the broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Seda County, in *Picea* and *Abies* forest, altitude 4000 m, 8 August 2023, Zuo H. Chen 33922 (MHHNU 33922); Kangding City, Mugecuo, in broad-leaved forest with Fagaceae, altitude 3500 m, 1 August 2012, Ping Zhang 1205

(MHHNU 7705); same city, Jiulong County, Tanggu Township, 18 July 2005, Zai W. 542 (HKAS49037).

Commentary: *Ramaria laeta* closely resembles *R. robustiflava*, as both species exhibit yellowish orange basidiomata, stout stipes, clamped hyphae and basidia, and a tendency to turn brown when bruised. The key distinction lies in their coloration: *R. laeta* leans towards an orange hue, while *R. robustiflava* tends towards a yellowish tint. Besides, *R. laeta* closely resembles *R. xizangensis* (basidiospores 10.69 × 4.29 μm; Zhou et al. 2024), but the former exhibits yellowish-orange basidiomata, whereas the latter has pinkish-toned basidiomata.

59. ***Ramaria robustiflava*** P. Zhang & J. Zhong, **sp. nov.** Fig. 21 e–f and Fig. 85

Mycobank: MB 853246

Etymology: *robustiflava* = *robust* + *flava*, referring to the species having a stout stipe and yellow-colored basidiomata.

Diagnosis: Basidiomata are yellow with stout stipes, and the basidiospores measure 11.08 × 4.57 μm with warts.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Muge Lake, in the *Abies* forest, altitude 3500 m, 2 September 2021, P. Zhang 3590 (Holotype, MHHNU 10890, GenBank Acc. No.: ITS = PP467234, nrLSU = PP493546, *tef1*-a = PP480413).

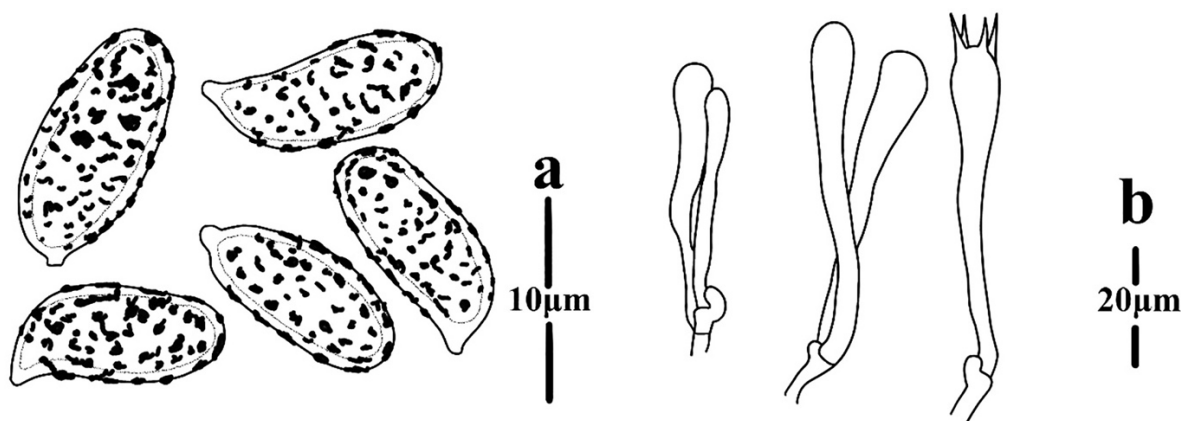


Fig. 85 Microscopic features of *R. robustiflava* (MHHNU 10090). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Description: *Basidiomata* 11 cm high and 10 cm broad, obovate in outline. *Stipe* 3 × 2 cm, single to falsely fasciculate, stout, with abortive branchlets, minutely pruinose between substrate particles and between stipes, off-white (1A1), brunnescent at base, weakly watery-brunnescent upward; flesh off-white (1A1), moist but not gelatinous or slippery. *Major branches* 3–5, flattened or terete, crowded, brunnescent or turned to lemon yellow (3B8) where handled, concolorous with stipe downward, yellowish orange (4A8) upward. *Branches* in 3–5 ranks, ascending, more or less terete, salmon (6A4) to yellowish orange (4A8); flesh more pallid, brittle to brittle-fibrous; internodes diminishing gradually at maturity; axils narrow rounded throughout. *Apices* short and broadly rounded when young, digitate when mature, double-dichotomous, concolorous with branches. Odor and taste faintly fabaceous.

Basidiospores [30/2/2] (10.0–)10.1–12.0(–12.9) × (3.8–)4.1–5.3(–5.4) µm, $L_m = 11.08$ µm, $l_m = 4.57$ µm, $Q = (2.01–)2.10–2.83(–2.99)$, $Q_m = 2.45 \pm 0.23$, ellipsoid, flattened adaxially, roughened in profile; wall up to 0.2 µm thick; hilar prominent; ornamentation of small and flat warts randomly scattered. *Basidia* 45–65 × 7–10 µm, clavate, clamped; sterigmata 4, stout, straight. *Subhymenium* extensive, double-dichotomous. *Hymenium* thickening. *Tramal hyphae of stipe* 3–14 µm wide, hyaline, conspicuously clamped, thick-walled (wall up to 1 µm thick), tightly interwoven, not agglutinated or adherent; ampulliform clamps up to 16 µm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* up to 4–15 µm wide, hyaline, conspicuously clamped, thin-walled, parallel, not agglutinated to adherent; ampulliform clamps and gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in forests dominated by *Picea*. *Basidiomata* occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Kunming, bought from mushroom market, 23 July 2017, P. Zhang 2598 (MHHNU 9098); Shangri-La, 8 September 2007, Feng Bang 113 (HKAS 52834); same city, Deqin County, Baima Snow Mountain Nature Reserve, altitude 3750 m, 17 August 2018, P. Zhang 3431 (MHHNU 9931), P. Zhang 3432 (MHHNU 9932), P. Zhang 3448 (MHHNU 9948); same location, altitude 3750 m, 18 August 2018, P. Zhang 3469 (MHHNU 9969).

Commentary: Dr. Zhang (2010) classified this species as *R. rubricarnata* var. *laeta* R.H. Petersen. Initially described by Marr & D.E. Stuntz, *R. rubricarnata* has been collected in North America, exhibiting four variants. *Ramaria rubricarnata* var. *verna* R.H. Petersen & Scates and *R. rubricarnata* var. *pallida* R.H. Petersen & Scates are both spring-fruiting species found in western North America. *Ramaria rubricarnata* Marr & D.E. Stuntz and *R. rubricarnata* var. *rubricarnata* were collected by Marr & D.E. Stuntz in October to November, characterized by basidiospores less than 10 µm in length, pallid fleshy-yellow branches, yellow apices, and salmon colored flesh.

Petersen (1989) described the variant *R. rubricarnata* var. *laeta* in Yunnan, China, noting its shorter basidiospores ($L_m = 10.17$ µm), salmon-orange branches, pastel gold to bright orange-yellow apices, brunnescent when bruised, and absence of abortive branchlets, collected in *Pines*

yunnanensis forests.

Further observations and molecular identifications of additional specimens have revealed the presence of abortive branchlets, and slightly longer basidiospores compared to *R. rubricarnata* var. *laeta* ($L_m = 10.17$ µm; Petersen & Watling 1989). These differences, including collections from *Picea* forests with salmon branches and bright orange-yellow apices, warrant the classification of *R. robustiflava* as a distinct taxon.

60. ***Ramaria xizangensis*** C.L. Zhao & H.M. Zhou, in Zhou, Zhang, Li, Wu & Zhao, MycoKeys 106: 216 (2024)

Original description in Zhao et al. (2024).

Ramaria* ser. *Laeviformosoides P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852710

Etymology: “laevi” refers to smooth basidiospores, while “formosoides” denotes similarity to *R. formosa*.

Type species: *R. laeviformosoides* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 384, 1989.

Diagnosis: *Basidiomata* displays weak salmon and yellow coloration; basidia are clamped and non-cyanophilous; basidiospores are smooth and weakly amyloid stipe flesh.

Commentary: A potential basonym, *Ramaria* sect. *Gypseae* Franchi & M. Marchetti, shares characteristics such as smooth basidiospores and predominantly white *basidiomata* rather than yellow. However, the type species of this section, *R. gypseae*, collected by Schild in 1982, has not been rediscovered since.

In China, two species were collected in this series. *Ramaria mediterranea* Schild & Franchi, which also features white *basidiomata* and purple apices in this series (Schild 1998; Franchi & Marchetti 2021). *Ramaria gypsea* Schild (1982) may also belong to this Series, characterized by white *basidiomata* and basidiospores measuring 10.8–14 × 3.7–4.5 µm with clamps. The type specimen originated from Italy but has not been rediscovered since Schild’s collection in 1982.

61. ***Ramaria laeviflava*** P. Zhang & J. Zhong, **sp. nov.** Fig. 22 a–b and Fig. 86

Mycobank: MB 853227

Etymology: *laeviflava* = *laevi* + *flava*, referring to the species having nearly smooth basidiospores and yellow *basidiomata*.

Diagnosis: *Basidiomata* are pallid salmon to yellow in color; basidia and hyphae exhibit clamps; basidiospores are nearly smooth; darkens to dark brown when bruised or handled.

Type: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3409 (Holotype, MHHNU 9909, GenBank Acc. No.: ITS = PP467285, nrLSU = PP493587).

Description: *Basidiomata* 10 cm high and 11 cm broad, medium sized, obtriangular in outline. *Stipe* 4 × 1.5 cm, single to falsely fasciculate, tapering gradually downward, smooth, off-white (1A1) to pastel yellow (2A4), without abortive branchlets; flesh solid, off-white (1A1) to yellowish white (2A2), moist, but not gelatinous or slippery. *Major branches* several, stout and short, terete to flattened, ascending, concolorous with stipe downward, concolorous with branches upward, weakly brunnescent. *Branches* in 3–4 ranks, dichotomous,

terete, ascending, yellowish white (2A2) to cream (4A3); flesh paler than hymenium, soft; internodes length ratio diminishing gradually at maturity; axils mostly acute, both U-shaped and V-shaped. *Apices* crowded, cuspidate, the ends

of the major branches are almost in the same plane, pastel yellow (2A4) to yellowish orange (4A8), concolorous with the branches in age; Odor faintly penetrating; taste negligible.

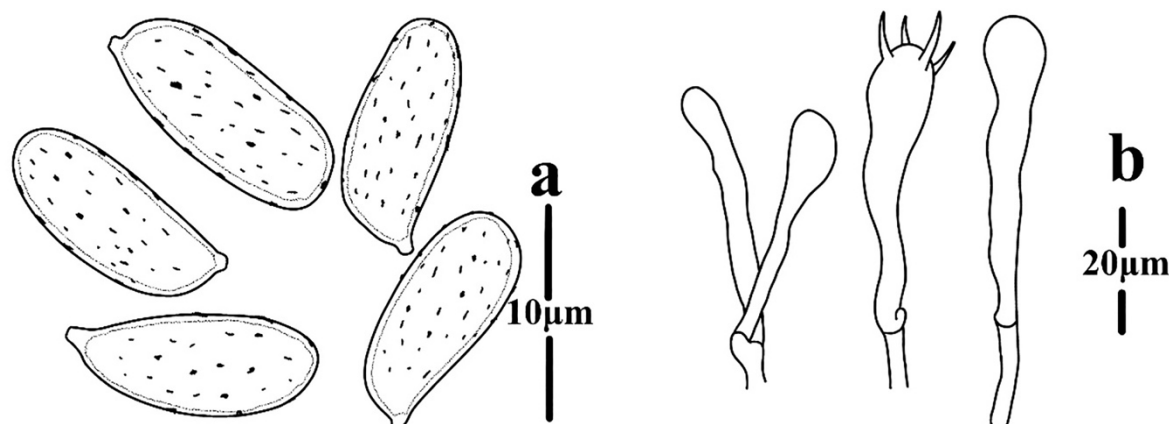


Fig. 86 Microscopic features of *R. laeviflava* (MHHNU 9909). a basidiospores; b basidia. Scale bars: a =10 μm, b =20 μm.

Basidiospores [62/2/2] (7.0–)7.5–11.8(–12.3) × (3.1–)3.3–5.1(–5.4) μm, $L_m = 9.56$ μm, $l_m = 4.11$ μm, $Q = (1.67–)1.91–2.71(–2.94)$, $Q_m = 2.33 \pm 0.26$, ellipsoid, nearly smooth in profile; hilar appendix prominent; ornamentation none or finely and small warts randomly placed. **Basidia** 35–50 × 5–11 μm, clavate, clamped; sterigmata 4, long, spindly, straight. **Subhymenium** rudimentary, pseudoparenchymatous. **Hymenium** unthickening. **Tramal hyphae of stipe** 4–15 μm wide, usually inflated, hyaline, thin- to thick walled, loosely parallel, interwoven, not agglutinated or adherent; ampulliform clamps up to 15 μm broad, thick-walled, with coarse ornamentation; gloeoplerous hyphae not observed; **Tramal hyphae of upper branches** up to 3–14 μm wide, hyaline, thin-to thick-walled, clamped, secondarily septum, loosely parallel, not agglutinated or adherent; ampulliform clamps up to 15 μm broad, thick-walled, unornamented; gloeoplerous hyphae not observed.

Ecology: Found in the forests with *Quercus semecarpifolia*; basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3406 (MHHNU 9906), P. Zhang 3407 (MHHNU 9907), P. Zhang 3410 (MHHNU 9910), P. Zhang 3411 (MHHNU 9911).

Commentary: *Ramaria laeviflava* bears a striking resemblance to *R. laeviformosoides*. Both species share similar-sized and nearly smooth basidiospores, clamped basidia and hyphae, and a comparable pale salmon to yellow basidiomata that darkens when bruised or handled. However, *R. laeviflava* is typically found in *Picea* forests, whereas *R. laeviformosoides* occurs in *Quercus* forests. In addition, *R. laeviformosoides* tends to have a relatively paler color (cream with a hint of salmon), while *R. laeviflavah* exhibits a more yellowish hue. *Ramaria laeviflava* is phylogenetically close to *R. mediterranea*, but the latter possesses smaller basidiospores (7.7 × 4.2 μm; Franchi & Marchetti 2021).

62. *Ramaria laeviformosoides* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 384, 1989. Fig. 22 c–d and Fig. 87

Description: Basidiomata 11 cm high and 7 cm broad,

small-sized, circular to broadly obovate in outline. **Stipe** 6 × 5 cm, single to falsely fasciculate, stout, tapering gradually downward, smooth upward, tomentose at base, with abortive branchlets, ridged to appear fasciculate, pruinose at base, smooth upward, with no abortive branchlets; white downward, weakly brunnescent; flesh white, solid, moist, but not gelatinous or slippery, soft, drying firm but easily penetrated, not friable, yellow downward. **Major branches** several, ascending, terete, concolorous with stipe downward, concolorous with branches upward, weakly brunnescent. **Branches** in 3–6 ranks, terete, strict, pallid flesh to pink colored, fading by maturity to cream; flesh paler than hymenium, soft; internodes all short when young, elongating from below, diminishing gradually upward at maturity; axils rounded throughout. **Apices** coarse, acute, divaricate when young, stiffly digitate at maturity, light ochraceous color when young, concolorous with the branches in age; Odor faintly penetrating; taste negligible.

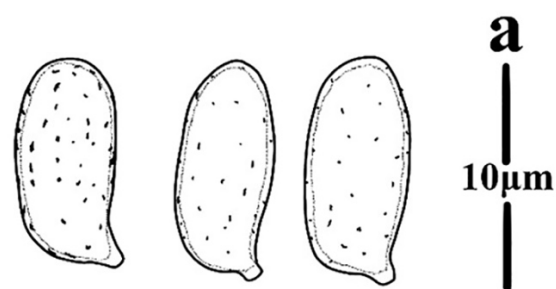


Fig. 87 Basidiospore features of *R. laeviformosoides* (MHHNU 8599). Scale bar: a = 10 μm.

Basidiospores [60/2/2] 7.0–9.5 × 3.5–4.2(–4.5) μm, $L_m = 8.56$ μm, $l_m = 3.89$ μm, $Q = (1.75–)1.84–2.57$, $Q_m = 2.19 \pm 0.23$, cylindrical, smooth, or extremely obscurely undulate in profile; wall up to 0.2 μm thick; hilar appendix small, not prominent, truncate; ornamentation none. **Basidia** 60–70 × 9–10 μm, clavate, clamped; sterigmata (2–) 4, short, spindly, straight. **Subhymenium** rudimentary, pseudoparenchymatous. **Hymenium** thickening. **Tramal hyphae of stipe** 3–23 μm wide,

usually inflated, hyaline, thin- to occasionally thick walled (wall up to 1 μm thick locally), interwoven, tightly packed, not agglutinated or adherent; ampulliform clamps up to 16 μm broad, thick-walled (wall up to 1.5 μm thick), with coarse ornamentation; gloeoplerous hyphae rare, as clavate cell tips, undelimited at narrow end, yellow-refrangent; *Tramal hyphae* of upper branches up to 3–12 μm wide, hyaline, thin-to thick-walled (wall up to 0.5 μm thick locally), clamped, secondarily septum, strictly parallel, not agglutinated or adherent; ampulliform clamps up to 14 μm broad, thick-walled (wall up to 1 μm thick), unornamented; gloeoplerous hyphae occasional, 2–3.5 μm , refrangent.

Ecology: Found in *Picea* forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, Lijiang mushroom market, 26 August 2008, Qi Zhao 8319 (HKAS 55281); Chuxiong, 17 August 2015, P. Zhang 2099 (MHNU 8599).

Commentary: Diagnostic characters for the species include the following: 1) pale salmon and yellow coloration; 2) clamped basidia; 3) smooth basidiospores; and 4) weakly amyloid stipe flesh.

The isotype designation (HKAS 17744) in Petersen's publication is erroneous, as the species exhibits warty basidiospores, which contradicts the smooth basidiospores that were described (Petersen & Zang 1989). Zhang's perspective is accurate because *R. laeviformosoides* stands out as the only smooth-spored *Ramaria* species lacking predominant yellow or orange coloration (Zhang 2010). It bears a resemblance to *R. formosa* in stature, browning tendency, and overall coloration. Notably, both species share characteristics such as soft stipe flesh when fresh and dry, and clamped basidia. However, they differ significantly in basidiospores morphology—*R. laeviformosoides* basidiospores are smooth without ornamentation, whereas *R. formosa* basidiospores are conspicuously roughened and coarsely ornamented. Additionally, the basidiomata of *R. laeviformosoides* exhibit more muted colors compared to *R.*

formosa. *Ramaria laeviformosoides* is phylogenetically close to *R. mediterranea*, but the latter possesses smaller basidiospores (7.7 $\times$ 4.2 μm ; Franchi & Marchetti 2021).

Ramaria* ser. *Leiosporae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852709

Etymology: *Leiosporae* = "*Leio*" + "*spora*", "*leios*" (λεῖος), meaning "smooth".

Type species: *Ramaria schildii* R.H. Petersen, *Mycologia* 80(2): 229 (1988).

Diagnosis: Basidiomata displays weak salmon and yellow coloration; basidia are clamped; basidiospores are smooth with electron microscope.

Commentary: In China, only one species has been collected in this series.

63. ***Ramaria schildii*** R. H. Petersen, *Mycologia* 80(2): 229 (1988). Fig. 23 a–b and Fig. 88

Description: Basidiomata 10–18 cm high, up to 5–10 cm broad, superficially obconical to trumpet-shaped in outline, but old basidiomata becoming lax and assuming semi-grotesque position. Stipe 2 $\times$ 3–5 cm, rooting to some extent, fasciculate or with a very small point of union at the base, or solitary, minutely tomentose and off-white below substrate, creamy above, becoming darker to tannish-ochre in age; surface obviously weakly brunnescent where handled; flesh white, fibrous-fleshy, moist but not slippery or gelatinous, slowly weakly brunnescent. Major branches few per fascicle, often terete or flattened, light yellow (with a hint of ochre) when young, fading to pale fleshy tan in age; flesh yellowish near hymenium; surface vinyescent around dirt specks and flesh slowly so when ripped; axils narrowly rounded to acute when young, often lunate in age; internodes diminishing gradually upward, giving an open, lax appearance. Apices short and straight, lemon yellow when young, becoming divaricate and lobed in age, and then fading through more ochre to finally concolorous with branches. Taste and odor not recorded.

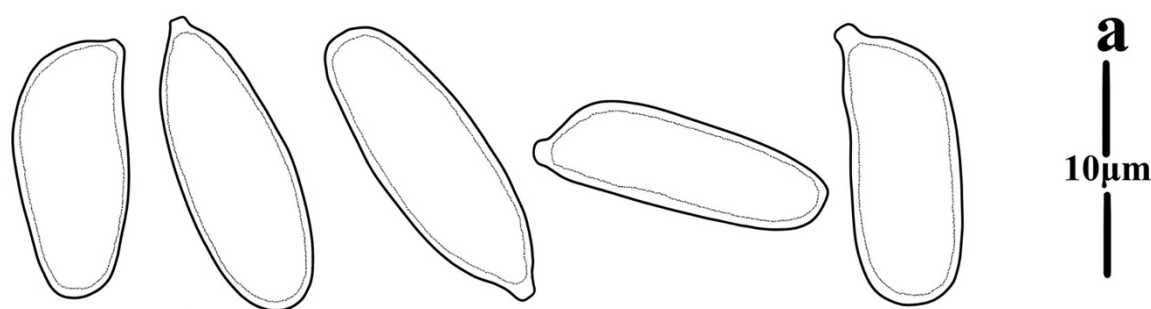


Fig. 88 Basidiospores of *R. schildii* (MHNU 9285). Scale bar: a = 10 μm .

Basidiospores [60/2/2](8.8–)9.3–14.0(–14.9) $\times$ (3.3–)3.4–5.1(–5.8) μm , L_m = 12.09 μm , l_m = 4.16 μm , Q = (2.2–)2.4–3.4(–3.5), Q_m = 2.85 $\pm$ 0.29, cylindrical, smooth in profile; wall up to 0.2 μm thick; hilar appendix truncates, somewhat prominent, abrupt. **Basidia** 40–65 $\times$ 9–12 μm , clavate, clamped; sterigmata 4, long, stout, slightly divergent. **Hymenium** thickening. **Tramal hyphae** of stipe hyaline, thin walled, clamped, weakly cyanophilous, of two types: 1) 3–13 μm wide, parallel, somewhat inflated; and 2) 1.6–2.0 μm wide,

tortuous, often with abundant side branches arising at almost right angles and usually ending as abortive pegs or short branches, infrequently clamped, locally densely interwoven with more inflated hyphae. Stipe surface hyphae identical to predominant flesh hyphae. **Tramal hyphae** of upper branches 3–10 μm wide, thin-walled, parallel, clamped, hyaline, free.

Ecology: Solitary or gregarious in forests with *Picea* or *Abies*.

Distribution: Known from southwestern China (Sichuan);

Italy and Sweden in Europe (Petersen 1988a).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Mugecuo, in a *Picea asperata* forest, altitude 3500 m, 21 August 2017, P. Zhang 2702 (MHHNU 9202); same city, Tagong Township, in a mixed forest of *Abies* and *Picea*, altitude of 3900m, 22 August 2017, P. Zhang 2727 (MHHNU 9227) and P. Zhang 2730 (MHHNU 9230); same city, Waze Township, in a mixed forest of *Abies* and *Picea*, altitude of 4000 m, 23 August 2017, P. Zhang 2742 (MHHNU 9242); same city, Gongga Township, in mixed forests dominated by *Picea asperata* and *Betula platyphylla*, altitude 3700 m, 27 August 2017, P. Zhang 2785 (MHHNU 9285). XIZANG AUTONOMOUS REGION: Changdu City, Leiwuqi County, August 2004, Zhu L. Yang 4378 (HKAS 45735).

Commentary: The species is the only one in *Ramaria* of China with smooth basidiospores.

Ramaria* ser. *Lineariflavae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852771

Etymology: *lineariflava* = *linear* + *flava*, indicating that this species has slender branches and yellowish fruitbodies.

Type: *R. lineariflava* P. Zhang & J. Zhong.

Diagnosis: Basidiomata displays yellow coloration; branches slender; basidia are clamped; basidiospores are small and warty.

Commentary: This series was collected in China and comprises one species, the other species is *R. flavosalmonicolor* Schild.

64. ***Ramaria lineariflava*** P. Zhang & J. Zhong, **sp. nov.** Fig. 24 a–b and Fig. 89

Mycobank: MB 853206

Etymology: *lineariflava* = *linear* + *flava*, indicating that this species has slender branches and yellowish basidiomata.

Diagnosis: Basidiomata are pale orange; stipe ranges from single to fasciculate; branches are slender; basidia are clamped; basidiospores are coarsely ornamented.

Type: CHINA, HUNAN PROVINCE: Chenzhou City, Yizhang County, Mangshan National Nature Reserve, altitude 1400 m. 5 September 2007, P. Zhang 662 (Holotype, MHHNU 7162, GenBank Acc. No.: ITS = PP467263, nrLSU = PP493569, *tef1-α* = PP480433).

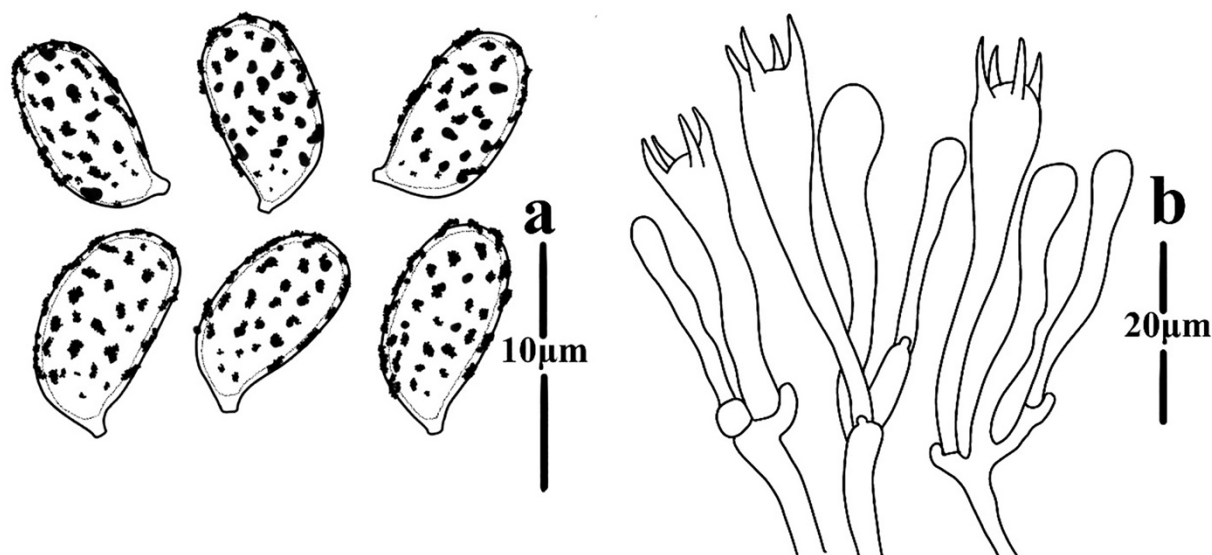


Fig. 89 Microscopic features of *R. lineariflava* (MHHNU 7162). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 14 cm high and 7 cm broad, repeatedly branched, usually obpyriforme in outline. *Stipe* 2 × 1.5 cm, single to falsely fasciculate, slender, tapering gradually downward, tomentose at base, smooth upward, without abortive branches, off-white (1A1) to cream (2A2), not changing color on bruising; flesh white, solid, moist but not gelatinous or slippery. *Major branches* 2–6, terete, up to 0.5 cm thick, ascending, concolorous to branches above. *Branches* in 4–6 ranks, ascending, polychotomous, slender, crowded; pale yellow (2A2–3), cream (2A2), pale orange (5A2–3); internodes diminishing gradually upwards at maturity; axils mostly acute (U-shaped). *Apices* narrowly rounded, concolorous with the branches. Odor negligible or faintly fresh; taste negligible.

Basidiospores [85/3/3] (6.0–)7.0–7.5(–9.0) × 3.0–4.0 µm, $L_m = 7.56$ µm, $l_m = 3.40$ µm, $Q = 1.75$ –2.67, $Q_m = 2.18 \pm 0.27$, thick-walled, cylindrical to ellipsoid, more or less flattened adaxially, conspicuously roughened in profile; wall up to 0.5 µm thick,

cyanophilous; hilar appendix prominent; ornamentation of prominent, discrete, low warts and short ridges randomly placed. *Basidia* 32–54 × 7–9 µm, clavate, thin-walled, hyaline, clamped at base, 4-spored; sterigmata 6–7 µm long. *Subhymenium* rudimentary. *Hymenium* unthickening. *Tramal hyphae of stipe* 3–15 µm wide, hyaline, thin-walled, clamped, interwoven; ampulliform clamps up to 14 µm broad, gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* 3–10 µm wide, hyaline, thin-walled, interwoven, loosely parallel, clamped; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved forests with Fagaceae or mixed forests dominated by Fagaceae, Oak and Pinaceae; basidiomata occurs in summer and autumn.

Distribution: Known from southwest, northeast, and central China (Yunnan, Jilin, Hunan, Hubei).

Additional materials examined: CHINA, JILIN PROVINCE: Tonghua County, Baijifeng Forest Park, in a temperate forest,

altitude 800 m, 28 Aug. 2020, P. Zhang 4043 (MHHNU 10543). HUNAN PROVINCE: Chenzhou City, Yizhang County, Mangshan National Nature Reserve, altitude 1400 m. 3 September 2007, P. Zhang 645 (MHHNU 7145); same location, 27 July 2018, P. Zhang 3247 (MHHNU 9747); HUBEI PROVINCE: Yichang County, Shennongjia, in a mixed forests of broad-leaved and coniferous, altitude 1100 m, 29 July 2006, P. Zhang 554 (MHHNU 7054). YUNNAN PROVINCE: Lijiang City, Yulong Snow Mountain, 7 September 1986, Petersen 47307 (HKAS 20046).

Commentary: The isotype species sequences of HKAS 20046, which Petersen identified as *R. hilaris* (Petersen & Zang 1989), actually cluster with *R. lineariflava* in our phylogenetic analyses. Examination of the HKAS 20046 specimen revealed an average basidiospore size of $7.3 \times 3.4 \mu\text{m}$ and without clamps, which is inconsistent with Petersen's description of *R. hilaris*. This confirms that HKAS 20046 represents *R. lineariflava* rather than *R. hilaris*. Moreover, *R. lineariflava* is characterized by smaller basidiospores than those of true *R. hilaris* ($9.7 \times 4.75 \mu\text{m}$, Petersen & Zang 1989) and exhibits clamps, which are absent in *R. hilaris*.

R. sandaracina (holotype from U.S.A.) could be mistaken for *R. lineariflava*. All have orange branches with clamped basidia, but *R. lineariflava* have stouter stipe and *R. sandaracina* have more darker orange color (Marr & Stuntz 1973).

Ramaria ser. Longisporae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852773

Etymology: “*longispora*” refers to long basidiospores.

Lectotype: *R. longispora* Marr & D.E. Stuntz, *Bibliotheca Mycol.* 38: 101.

Diagnosis: 1) flesh fleshy to fibrous; 2) Basidiomata are yellow to bright orange, without brown or red-brown patches; 3) long basidiospores; 4) long basidia and without clamps.

Commentary: One species of this series was collected in China. The other species, *R. longispora* Marr & D.E. Stuntz are found in North American, *R. atractospora* Franchi & M. Marchetti and *R. rielii* Boudhowever are found in Europe. All species within this series possess bright yellow color fruiting bodies and exhibit long basidiospores.

65. ***Ramaria pseudolongispora*** P. Zhang & J. Zhong, **sp. nov.** Fig. 25 a–b and Fig. 90

Mycobank: MB 853222

Etymology: “*pseudolongispora*” refers to the species having long basidiospores and being similar to *R. longispora*.

Diagnosis: Stipe context ranges from fleshy to fibrous; basidiomata are yellow to bright orange, lacking brown to red-brown stains; basidiospores are long; basidia are long and feature clamps.

Type: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, in the forest with *Quercus semecarpifolia*, altitude 3400 m, 14 August 2018, P. Zhang 3388 (Holotype, MHHNU 9888, GenBank Acc. No.: ITS = PP467183, nrLSU = PP493504, *tef1-α* = PP480388).

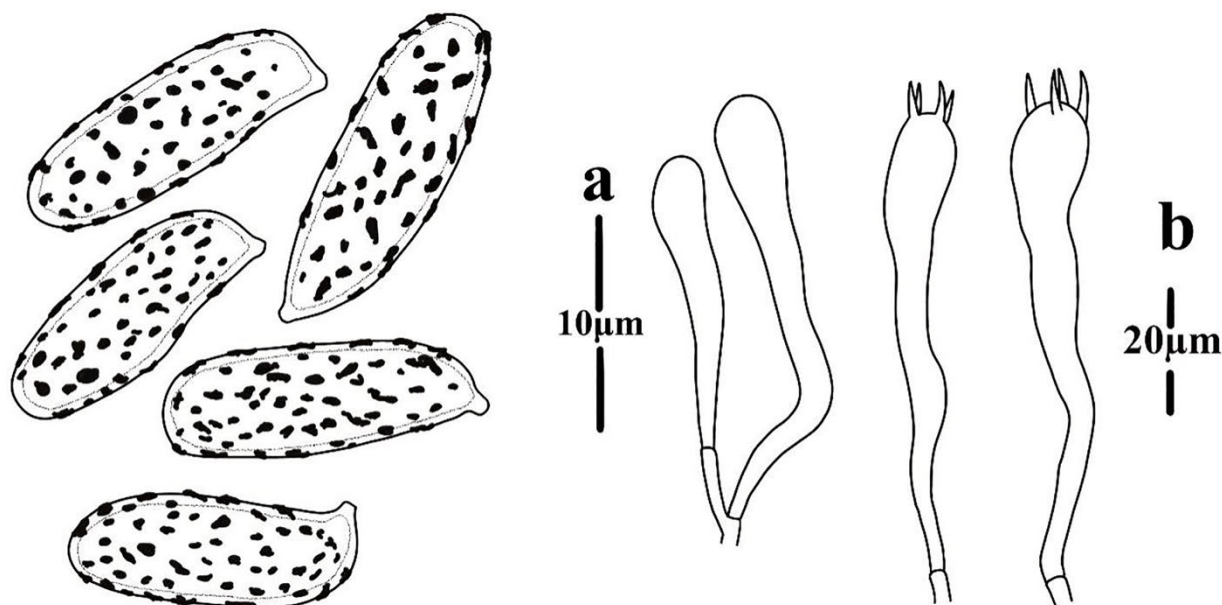


Fig. 90 Microscopic features of *R. pseudolongispora* (MHHNU 10059). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Description: *Basidiomata* 11–12 cm high and 4–6 cm broad, small to medium sized. *Stipes* up to 0.5–1 $\times$ 3–5 cm, single, or more commonly sub-compound, consisting of 2–6 primary axes arising from a primary root-like structure; off-white (1A1) at base, surface pale yellow (2A3) to sunflower yellow (4A7); not changing color on bruising; surface smooth or rugose, hardly erect; without abortive branches; context of stipe pale orange (5A3) when fresh, fleshy to fibrous, not slippery or soapy to the touch. *Major branches* 2–6,

polychotomous, erect, more or less terete; *Branches* in 3–6 ranks, commonly dichotomous; pale orange (5A3) to melon yellow (5A6) by maturity; axils narrowly rounded, mostly V-shaped; internodes length ratio diminishing gradually at maturity, distinctly elongated at maturity; context of main branches and upper branches fleshy to fibrous, pale orange (5A3), not slippery; *Apices* generally subacute, sometimes swollen, dichotomous, vivid yellow (2A8) to yellowish orange (4A8), concolorous with branches at maturity. Odor negligible;

taste weak, pleasant.

Basidiospores [60/2/2] (12.1–)13.1–16.9(–18.1) × (4.2–)4.5–6.1(–7.3) µm, $L_m = 14.95$ µm, $l_m = 5.19$ µm, $Q = (2.26\text{--})2.46\text{--}3.27\text{--}(3.94)$, $Q_m = 2.89 \pm 0.29$, cylindrical to long ellipsoid; roughened in profile; ornamentation of numerous, distinct, cyanophilous warts. hilar appendix moderate; **Basidia** 60–80 × 8–12 µm, long, clavate, without basal clamps; sterigmata 4, 4–7 µm long, straight. **Hymenium** unthickening, 75–90 µm; **Subhymenium** rudimentary, 10–25 µm. **Contextual hyphae**: Tramal hyphae of stipe 3–12 µm wide, loosely parallel, not adherent; inflated clamps up to 15 µm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, inflated clamps up to 15 µm broad, hyaline, thin-walled, unornamented; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved or mixed forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Xizang, Yunnan, Sichuan).

Additional materials examined: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3527 (MHHNU 10027), P. Zhang 3534 (MHHNU 10034), P. Zhang 3537 (MHHNU 10037), P. Zhang 3549 (MHHNU 10049), P. Zhang 3550 (MHHNU 10050), P. Zhang 3553 (MHHNU 10053), P. Zhang 3554 (MHHNU 10054), P. Zhang 3554 (MHHNU 10059). YUNNAN PROVINCE: Shangri-La, Pudacuo, in the forest with *Quercus semecarpifolia*, altitude 3400 m, 14 August 2018, P. Zhang 3389 (MHHNU 9889). SICHUAN PROVINCE: Ganzi, Kangding City, Waze Township, in a mixed forest of *Abies* and *Picea*, altitude of 4000 m, 23 August 2017, P. Zhang 2741 (MHHNU 9241).

Commentary: In the field, this species is often mistaken for *R. largentii*, *R. sandaracina*, *R. gelatiniaurantia*, *R. aurantiisiccescens* due to their similar coloration. However, the first two species can be distinguished by their clamped hyphae, while the latter two differ in various aspects, including basidiospores dimensions.

Additionally, species like *R. longispora* from North

America, *R. rielii* Boud and *R. atractospora* Franchi & M. Marchetti from Italy share a similar yellowish basidiomata and elongated basidiospores. Distinguishing factor lies in the basidiospores morphology: *R. rielii* has slightly narrower and longer (13.5–18.0 × 3.5–5.0 µm, $L_m = 14.9$ µm, $l_m = 4.4$ µm, $Q = 2.7\text{--}4.1$, $Q_m = 3.4$, Franchi & Marchetti 2021), whereas *R. longispora* and *R. atractospora* have slightly smaller basidiospores in size (Marr & Stuntz 1973; Franchi & Marchetti 2021).

Ramaria ser. Luteae (Franchi & M. Marchetti) P. Zhang & J. Zhong **stat. nov.**

Synonym: *Ramaria* sect. *Luteae* Franchi & M. Marchetti, Fungi Non Delineati, Raro vel Haud Perspecte et Explore Descripti aut Definite Picti 16: 32 (2001)

Diagnosis: *Basidiomata* terrestrial, cream to yellow, with more brightly colored apices or branches that are concolorous; clamps absent, basidiospores pale ochraceous, more or less verrucose, longitudinally striated or smooth.

Type species: *Ramaria lutea* (Vitt.) Schild, *Persoonia* Vol. 9 (3): 409, 1977.

Description: This series includes one species collected in China.

66. ***Ramaria sanguinixantha*** P. Zhang & J. Zhong, **sp. nov.** Fig. 26 a–b and Fig. 91

Mycobank: MB 853234

Etymology: *sanguinixantha* = "sanguini-" + "-xantha", referring to the yellow basidiomata that turn blood-red when injured.

Diagnosis: *Basidiomata* exhibits a salmon to yellow hue with apices that are yellow or concolorous with the branches, turning to blood-red when injured, and the base of basidia and hyphae lack clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4342 (Holotype, MHHNU 10842, GenBank Acc. No.: ITS = PP467240, nrLSU = PP493550, *tef1-α* = PP480416).

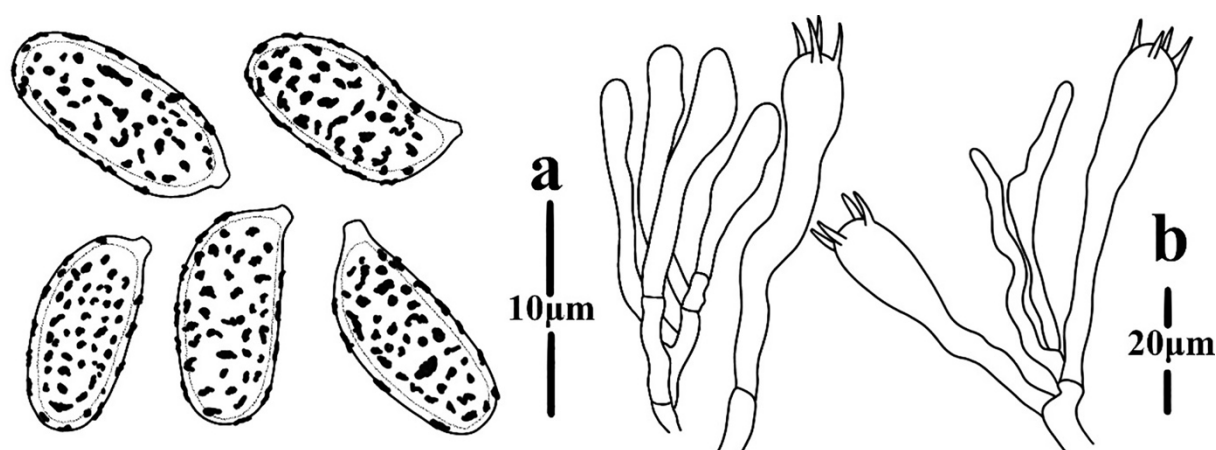


Fig. 91 Microscopic features of *R. sanguinixantha* (MHHNU 10842). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 11 cm high and 15 cm broad, obtriangular to usually subcircular in outline. *Stipe* 4 × 4 cm, single to falsely fasciculate, tapering to narrowly abounded base, smooth, with occasional abortive branchlets, brunnescent when injury; flesh off-white (1A1), moist but not

gelatinous or slippery. *Major branches* several, terete, pale yellow (2A3) to salmon (6A4). *Branches* in 2–6 ranks, ascending, terete, pale yellow (2A3) to salmon (6A4); flesh more pallid, brittle to brittle-fibrous, gelatinous; internodes diminishing gradually at maturity; axils narrowly rounded

throughout. *Apices* short and crowded, double-dichotomous, pale yellow (2A3), turned to wine red (11D8) when injury. Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (8.1–)8.7–11.2(–11.9) × (3.4–)4.0–5.2(–5.9) µm, $L_m = 9.97$ µm, $l_m = 4.50$ µm, $Q = (1.82\text{--})2.00\text{--}2.56(–2.87)$, $Q_m = 2.23 \pm 0.19$, subcylindrical to ellipsoid, slightly roughened in profile; hilar not prominent; ornamentation of small, randomly scattered flat warts. *Basidia* 30–60 × 5–10 µm, clavate, without clamps; sterigmata 4, stout and straight. *Subhymenium* extensive, hyphae. *Hymenium* unthickening. *Tramal hyphae of stipe* 5–13 µm wide, hyaline, without clamps, tightly interwoven, not agglutinated or adherent; ampulliform clamps up to 16 µm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* up to 4–15 µm wide, hyaline, thin walled, without clamped, loosely parallel, more inflated inward, agglutinated to adherent; ampulliform clamps up to 16 µm broad, gloeoplerous hyphae occasionally.

Ecology: In *Quercus* or *Picea* forests or broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Sichuan, Xizang, Yunnan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4363 (MHHNU 10863);

same location, altitude 3900 m, 6 September 2021, P. Zhang 4317 (MHHNU 10817); same city, Sewulong Village, within a *Quercus* forest, altitude 3700 m, 3 September 2018, P. Zhang 3594 (MHHNU 10094); same city, Gongga Township, Sewurong II Village, altitude 3700 m, 26 August 2017, P. Zhang 2772 (MHHNU 9272), P. Zhang 2773 (MHHNU 9273); same city, Pengta Township, altitude 3100 m, 19 August 2017, P. Zhang 2678 (MHHNU 9178). XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3548 (MHHNU 10048), 3561 (MHHNU 10061); same location, altitude 3400 m, 26 August 2018, P. Zhang 3524 (MHHNU 10024). YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the mixed forest with *Quercus* and *Picea*, altitude 3429 m, 10 August 2020, Jian W. Liu MF367 (MHHNU 11647); same location, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3416 (MHHNU 9916) and P. Zhang 3424 (MHHNU 9924).

Commentary: Reddish-brown staining species are distributed worldwide, with a total of 11 species reported. Among these, five species possess clamps (*R. cystidiophora* var. *maculans*, *R. maculatipes*, *R. vinosimaculans*, *R. eosanguinea*, *R. sanguinipes*), and six species without clamps (*R. rubribrunnescentiflava*, *R. synaptopoda*, *R. rubiginosa*, *R. sanguinea*, *R. rubriattenuipes*, *R. xanthosperma*). The main characteristics of each species are as follows.

Table 1 Eleven globally reported reddish-brown staining species: clamps features and basidiospore size

Species with clamps	Basidiospore size	Species without clamps	Basidiospore size
<i>R. cystidiophora</i> var. <i>maculans</i>	11.8 × 4.0 µm	<i>R. rubribrunnescentiflava</i>	12.3 × 4.4 µm
<i>R. maculatipes</i>	10.2 × 4.3 µm	<i>R. synaptopoda</i>	9.9 × 4.1 µm
<i>R. vinosimaculans</i>	12.5 × 4.6 µm	<i>R. rubiginosa</i>	9.4 × 4.4 µm
<i>R. eosanguinea</i>	11.3 × 4.4 µm	<i>R. sanguinea</i>	9.7 × 4.0 µm
<i>R. sanguinipes</i>	10.5 × 4.6 µm	<i>R. rubriattenuipes</i>	13.4 × 5.0 µm
		<i>R. xanthosperma</i>	12.7 × 4.4 µm

Among the species without clamps, *R. rubribrunnescentiflava*, *R. rubriattenuipes* and *R. xanthosperma* have basidiospores sizes greater than 10 µm, while *R. sanguinea* and other two species have basidiospores sizes smaller than 10 µm.

Compared to the other two species with similar basidiospores sizes, *R. synaptopoda* is distinguished by its a pronounced fasciculate habit and small basidiomata, resembling *R. conjunctipes*.

Marr & Stuntz questioned the application of *R. sanguinea* (Pers.) Quél. Coker identified his specimens based on a colored illustration and Persoon's original description, and according to Corner, "the exact identity of *Clavaria sanguinea* Per. is debatable". In 1968, Marr considered the collection now known as *R. rubiginosa*, to be *R. sanguinea* as described by Coker (1923). Since then, Marr examined the collections that formed the basis of Coker's description and found differences: Marr's specimens were more robust with broader stipes, and larger, more finely ornamented basidiospores, In

1966, Corner reclassified *R. sanguinea* (formerly *C. sanguinea*) as a variety of *R. flava* (Schaeff.) Quél., designating Coker No. 2656 (NCU) as the type specimen. To clarify whether *R. sanguinea* should be understood in Persoon's sense, a type specimen from Persoon's collections needs identification or a neotype must be designated from the type locality. Based on color notes from Doty (1944) and examination of two collections he cited, Marr concluded that *C. sanguinea* sensu differs from *R. rubiginosa*.

When comparing the eastern *R. xanthosperma* (Peck) Corner with the western *R. rubiginosa* and *R. sanguinea*, Petersen (1976) observed that *R. rubiginosa* "shows a generally brighter yellow coloration in the lower branches, stouter fruit bodies, positive reaction of branch trama with iron salts, and slightly smaller basidiospores." He further commented that if this combination of characteristics did not sufficiently distinguish the taxon at the species level, "*R. rubiginosa* would appear as a synonym under *R. sanguinea*."

For comparisons between *R. rubiginosa* and *R.*

sanguinixantha, the former collected in the western Hemlock Forest in Washington, USA, while the latter was collected in *Quercus*, *Picea*, or broad-leaved forests in the highlands of China.

In comparing *R. sanguinea* described by Franchi & Marchetti with *R. sanguinixantha*, our two-gene phylogenetic analysis indicates that are similar but not identical species. Morphologically, the species found in Italy displays a bright yellow color, with bruising brownish, and is collected in *Fagus sylvatica* and *Abies alba* forests. In contrast, *R. sanguinixantha* in China shows deeper wine-red bruising and tends to have salmon-colored basidiomata.

Ramaria ser. Nanisporae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852717

Etymology: “*nanis*” meaning “small or short”, is proposing because the short spore.

Type species: *R. nanispora* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 389 (1989).

Diagnosis: 1) Basidiomata with salmon to yellow-orange branches; 2) Bright orange flesh; 3) Stipe flesh weakly

amyloid; 4) Basidiospores short and small.

Commentary: This series includes three species collected in China. Additionally, other species such as *R. araiospora* Marr & D.E. Stuntz from North America, and its variants: *R. araiospora* var. *araiospora* Marr & D.E. Stuntz, *R. araiospora* var. *rubella* Marr & D.E. Stuntz, *R. fagetorum* Maas Geest. ex Schild, and *R. subbotrytis* (Coker) Corner are also part of this group.

67. **Ramaria corallina** P. Zhang & J. Zhong, **sp. nov.** Fig. 27 a–b and Fig. 92

Mycobank: MB 853184

Etymology: “*corallina*” refers to the coral red color of the basidiomata.

Diagnosis: This species is distinguished within its series by its coral-red basidiomata and basidiospores measuring less than 9 µm in length.

Type: CHINA, YUNNAN PROVINCE: Qujing City, Qilin District, near Longyuan Zhumushan Wind Farm, altitude 2250 m, 19 August 2022, P. Zhang 4712 (Holotype, MHHNU 11212, GenBank Acc. No.: ITS = PP467305, nrLSU = PP493603).

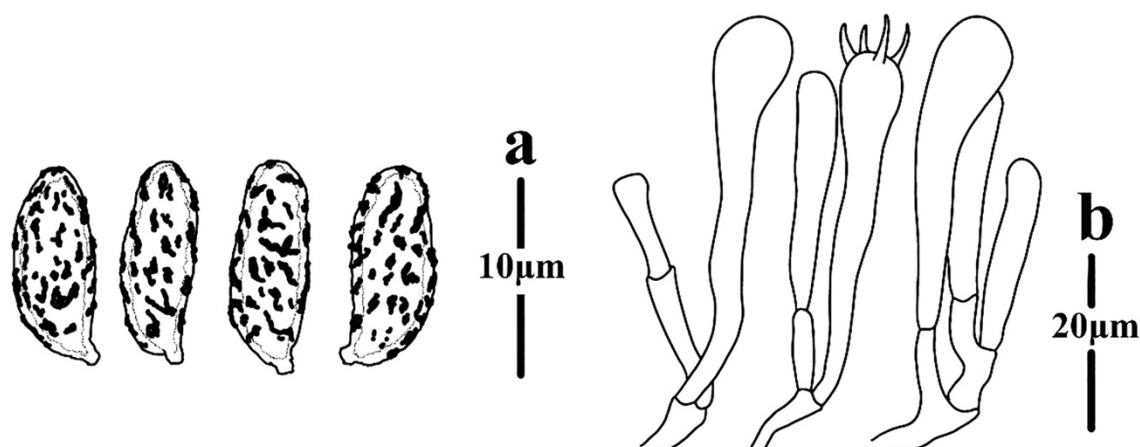


Fig. 92 Microscopic features of *R. corallina* (MHHNU 11212). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: Basidiomata 9 cm high and 5 cm broad, elongate obpyriform to obovate in outline. Stipe 3 × 2 cm, tapering gradually downward, single to falsely fasciculate, without abortive branches, not changing color on bruising, off-white (1A1) below, upward light red (10A5) to coral red (9B7), concolorous to branches above; flesh off-white (1A1) to shell pink (8A3), solid, not slippery, Major branches 2–6, ascending, terete, light red (10A5) to coral red (9B7), concolorous to branches. Branches in 4–6 ranks, light red (10A5) to coral red (9B7), sometimes with a light orange (5A5) tinge; internodes diminishing gradually upwards at maturity; axils narrowly rounded when young, broadly rounded at age. Apices broadly rounded, dichotomous, stiffly digitate, finally concolorous with branches. Odor faintly fragrant to middle; taste negligible.

Basidiospores [30/1/1] (7.6–)8.0–9.8(–10.1) × (2.9–)3.0–4.3 µm, $L_m = 8.67$ µm, $L_m = 3.64$ µm, $Q = (1.90\text{--})2.04\text{--}2.90\text{--}(2.98)$, $Q_m = 2.40 \pm 0.23$, ellipsoid to subcylindrical, roughened in profile; hilar appendix broad; ornamentation of prominent, discrete, low warts and short meandering ridges. **Basidia** 75–92 × 11–13 µm, clavate, without clamps; sterigmata 4, stout, straight. **Subhymenium** rudimentary, hyphal. **Hymenium** unthickening. **Tramal hyphae** of stipe 5–16 µm

wide, hyaline, virtually unclamped, thin to thick walled, interwoven, not agglutinated or adherent; ampulliform clamps up to 15 µm broad, not unusually thick-walled, with extensive, coarse, stalactitiform ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae** of upper branches 5–12 µm wide, hyaline, usually without clamps, usually inflated, parallel, not agglutinated or adherent, loosely parallel; ampulliform clamps up to 12 µm broad; gloeoplerous hyphae not observed.

Ecology: Gregarious on soil in mixed forests dominated by *Acer*, *Quercus* and *Pinus*; basidiomata occurs in autumn.

Distribution: Known from northeast China and southwest China (Yunnan, Jilin, Liaoning).

Additional materials examined: CHINA, JILIN PROVINCE: Tonghua County, Baijifeng Forest Park, in mixed forests dominated by *Acer*, *Quercus* and *Pinus*, altitude 800 m, 28 Aug. 2020, P. Zhang 4040 (MHHNU 10540), P. Zhang 4041 (MHHNU 10541), P. Zhang 4047 (MHHNU 10547). LIAONING PROVINCE: Liaodong Peninsula, in broad-leaved forest, 30 August 2018, P. Zhang 3610 (MHHNU 10110).

Commentary: *Ramaria corallina* shares similarities in appearance with *R. rubrosporula* and *R. nanispora* supported by our two-gene phylogenetic analysis indicating close

genetic relationships among them. However, these species can be distinguished as follows: *R. rubrosporula* typically has a stouter stipe often longitudinally rugulose, while *R. nanispora* exhibits clamps at the base of basidia and hyphae. Other morphologically similar species include *R. cyaneigranosa* (basidiospores $9.6 \times 4.7 \mu\text{m}$; Marr & Stuntz, 1973) and *R. stuntzii*, however, *R. cyaneigranosa* possesses longer basidiospores, while *R. stuntzii* exhibits more reddish basidiomata.

68. ***Ramaria nanispora*** R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 389, 1989. Fig. 27 c–d and Fig. 93

Description: Basidiomata 10 cm high and 7 cm broad. Stipe 3×1.5 cm, modest, tapering to narrowly rounded base, smooth, without abortive branchlet, off-white, weakly watery brunnescent when handled; flesh white, solid, fibrous, not gelatinous or slippery. Major branches several, ascending, flattened, congested upward, concolorous to branches. Branches in 3–7 ranks, terete, salmon colored, retaining orange coloration when dried; flesh brittle, snappy, bright salmon orange; internodes diminishing gradually at maturity; axils rounded throughout. Apices narrowly rounded double-dichotomous, curved-digitate, pale cream color to fleshy cream colored. Odor and taste weakly fabaceous.



Fig. 93 Basidiospores of *R. nanispora* (MHHNU 11636). Scale bar: a = 10 μm .

Basidiospores $[40/2/2] (7.0\text{--}8.0\text{--}10.5\text{--}12.0) \times 3.5\text{--}4.0 \mu\text{m}$, $L_m = 9.14 \mu\text{m}$, $l_m = 3.71 \mu\text{m}$, $Q = (2.00\text{--}2.24\text{--}3.00)$, $Q_m = 2.47 \pm 0.24$, cylindrical, minutely rough in profile; wall up to $0.2 \mu\text{m}$ thick; hilar appendix gradual, not prominent; ornamentation of small, irregularly shaped plates randomly oriented. **Basidia** $48\text{--}55 \times 8\text{--}9 \mu\text{m}$, clavate, clamped, congested; contents usually homogeneous distally, granular proximally, the granules refringent; sterigmata 4, straight slender. **Subhymenium** rudimentary. **Hymenium** unthickening. **Tramal hyphae of stipe** $3\text{--}10 \mu\text{m}$ wide, hyaline, thick-walled (wall up to $1 \mu\text{m}$ thick), very tightly interwoven, clamped, not agglutinated or adherent; ampulliform clamps common, up to $14 \mu\text{m}$ broad, symmetrical, blunt, thick-walled (wall up to $1.5 \mu\text{m}$ thick), with coarse ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** $3\text{--}11 \mu\text{m}$ wide, hyaline, thin-walled, inconspicuously clamped or often unclamped, secondarily septate, short celled, strictly parallel, adherent to free; ampulliform clamps and gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in forests dominated by *Pinus Yunnanensis*; basidiomata occur in autumn.

Distribution: Known from southwestern China (Yunnan)

(Petersen & Zang 1989; Zhang et al. 2005).

Additional materials examined: CHINA, YUNNAN PROVINCE: Dali, Er Yuan County, San Ying Town market, 27 August 1986, No.47293 (Holotype, TENN; isotype, HKAS); Kunming, Qiongzhusi, in a mixed forest with Fagaceae and Pinaceae, altitude 2000 m, 6 August 2006, Jun-Feng Liang 471 (HKAS 50198); Chuxiong, Nanhua County, Majie Town, Dazhongshan Nature Reserve, in broad-leaved forest dominated by Fagaceae, altitude 458 m, 24 August 2015, Jian W. Liu 368 (MHHNU 11636).

Commentary: The diagnostic features of *R. nanispora* are distinctive within *Ramaria*s.l. Its basidiomata displays a salmon-yellow color pattern, accompanied by bright orange branch flesh. The presence of clamped, short basidia and weakly amyloid stipe flesh further characterize this species. Additionally, it is notable for its small, cylindrical basidiospores.

The bright salmon-orange branch flesh of *R. nanispora* resembles that of *R. ephemeroforma*, however, *R. ephemeroforma* lacks clamps and exhibits gelatinous flesh. Similarly, *R. nanispora* shares similarities with *R. leptiformosa* in terms of salmon branches and cream-colored apices (Marr & Stuntz 1973), but *R. leptiformosa* differs significantly with its linear basidiomata structure and non-amyloid stipe flesh. Another comparable species, *R. rubricarnata*, shares similar colors and amyloid stipe flesh characteristics, but it differs in basidiomata stature and larger basidiospores size (average length of $9.8 \mu\text{m}$ across all varieties).

Sharda (1983) previously classified a taxon under *R. sandaracina* Marr & Stuntz or proposed it as a new variety of that species. In Sharda's concept, *R. sandaracina* included orange branches and apices, with basidiospores averaging $8.5 \mu\text{m}$ in length. A variant labeled as "*R. sandaracina* var. nov." described apices as "deep yellow" white flesh (likely referring to stipe flesh), and basidiospores measuring $5.6\text{--}7 (-7.5) \times 3\text{--}3.5 \mu\text{m}$.

69. ***Ramaria rubrosporula*** P. Zhang & J. Zhong, sp. nov. Fig. 27 e–f and Fig. 94

Mycobank: MB 853194

Etymology: *rubrosporula* = "*rubro*-" + "*sporosa*", proposed because the species has small basidiospores and red to orange-color basidiomata.

Diagnosis: Basidiomata are red to orange colored; apices are yellow or paler than upper branches; basidia are non-clamped and basidiospores are coarsely ornamented, averaging $10.43 \times 3.78 \mu\text{m}$.

Type: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3421 (Holotype, MHHNU 9921, GenBank Acc. No.: ITS = PP467257, nrLSU = PP493563, *tef1*- α = PP480429).

Description: Basidiomata 9 cm high and 7 cm broad. Stipe 2×2 cm, single to falsely fasciculate, stout, tapering gradually downward or rounded at base, somewhat rugulose, with no abortive branchlets, off-white (1A1) to salmon (6A4) below, yellowish orange (4A8) to carrot red (6B7) above, not changing color on bruising. flesh off-white (1A1), solid, not gelatinous or slippery. Major branches 1–2, stout, terete to flattened, concolorous to branches. Branches in 2–4 ranks, yellowish orange (4A8) when young, in age tend to carrot red (6B7) with a light red (10A5) color; internodes diminishing

gradually upwards at maturity; axils narrowly rounded (V shaped). Apices double-dichotomous, narrowly rounded to broadly rounded, crowded, yellowish orange (4A8) to carrot

red (6B7). Odor faintly fragrant to middle fresh, taste negligible.

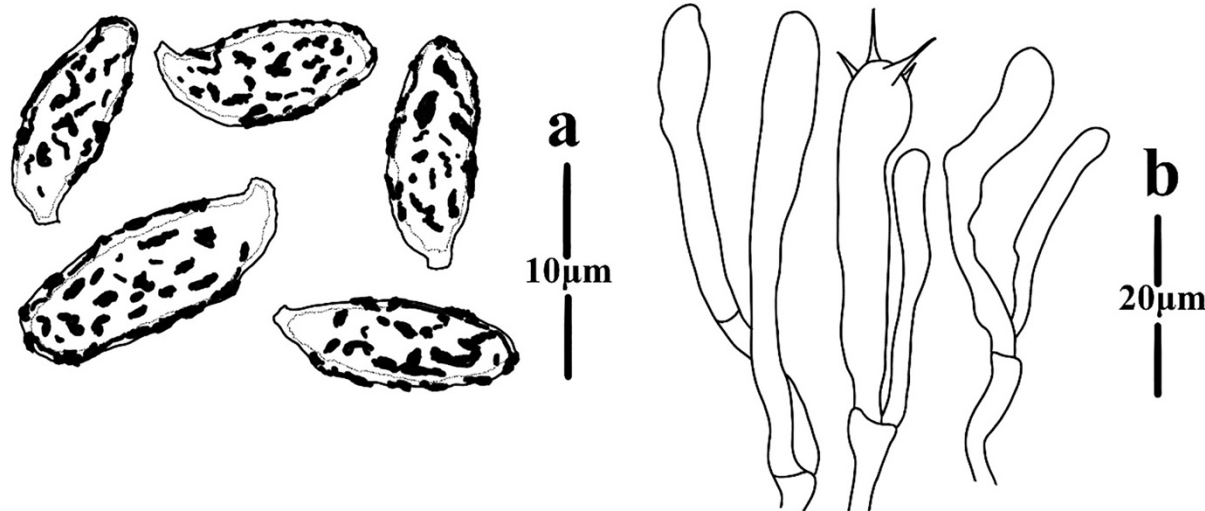


Fig. 94 Microscopic features of *R. rubrosporula* (MHHNU 9921). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [30/2/1] (9.3–)9.6–11.7(–12.9) × (3.1–)3.3–4.6(–4.7) μm, $L_m = 10.38$ μm, $l_m = 3.78$ μm, $Q = (2.30)–2.39–3.20(–3.36)$, $Q_m = 2.77 \pm 0.24$, subcylindrical, conspicuously roughened in profile, flattened adaxially; hilar appendix prominent; ornamentation of meandering and anastomosing ridges and warts. **Basidia** 35–75 × 8–12 μm, clavate, without clamp at base; sterigmata 4, stout and short. **Subhymenium** rudimentary, pseudoparenchymatous. **Hymenium** unthickening. **Tramal hyphae of stipe** 6–16 μm wide, hyaline, without clamp, thin to thick walled (wall up to 1 μm thick), loosely parallel, not agglutinated or adherent; ampulliform clamps up to 14 μm broad, not unusually thick-walled; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** 4–10 μm wide, hyaline, without clamps, thick-walled (wall up to 1 μm thick), usually inflated, parallel, not agglutinated or adherent, tightly packed; ampulliform swellings not observed; gloeoplerous hyphae hardly discernable.

Ecology: Solitary or gregarious on soil in high-altitude forests with *Picea* and *Betula platyphylla*; basidiomata occurs in autumn.

Distribution: Known from southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La, Pudacuo, Shudu Lake, in the forest with *Quercus semecarpifolia*, altitude 3600 m, 15 August 2018, P. Zhang 3418 (MHHNU 9918). Ganzi, Kangding City, Gongga Township, Sewulong 2 village, in mixed forests dominated by *Picea* and *Betula platyphylla*, altitude 3700 m, 27 August 2017, P. Zhang 2788 (MHHNU 9288).

Commentary: *Ramaria rubrosporula* shares significant morphological similarities with *R. corallina* and *R. nanispora* (basidiospore 8.67 × 3.64 μm and 9.14 × 3.71 μm, as measured in this study). However, the distinguishing feature lies in the length of the basidiospores, with *R. rubrosporula* possessing longer basidiospores. Additionally, *R. rubrosporula* bears resemblance to *R. araiospora* and *R. stuntzii*, although these species have not been documented in China. *Ramaria araiospora* is characterized by a rounded base, while *R. stuntzii* typically exhibits a tendency towards

red-colored basidiomata. Notably, *R. rubrosporula* has only been observed in high altitude locations in southwestern China.

Ramaria* ser. *Neoformosae (Franchi & M. Marchetti) P. Zhang & J. Zhong **stat. nov.**

Synonym: *Ramaria* sect. *Neoformosae* Franchi & M. Marchetti, Fungi Non Delineati, Raro vel Haud Perspecte et Explorate Descripti aut Definite Picti 16: 34 (2001).

Type species: *R. flavicingula* R.H. Petersen, Persoonia 14(1): 28 (1989).

Diagnosis: Basidiomata are yellow to salmon colored; flesh is gelatinous; color may change upon injury; basidia may or may not clamps; branches are slender.

Commentary: This series encompasses a diversity of species, with twenty species collected in China and over fourteen species from other countries. Among them are notable species such as *R. cistophila* P.P. Daniëls, *R. admiratia* R.H. Petersen, *R. acrisiccescens* Marr & D.E. Stuntz, *R. praecox* Schild, *R. parecox* var. *luteovenalis* (Franchi, M. Marchetti & Bottoni) Franchi, M. Marchetti & Bottoni, *R. calvodistalis* R.H. Petersen, *R. aurantiisiccescens* Marr & D.E. Stuntz, *R. flavicingula* R.H. Petersen, *R. luteoaurantiaca* Franchi & M. Marchetti, *R. subtilis* (Pers.) Quél., *R. albidoflava* Schild, *R. dendrophora* G.C. González, *R. lagentii* Marr & D.E. Stuntz, *R. aurea* (Schaeff.) Quél.

70. *Ramaria aurantiformosa* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 a–b and Fig. 95

Mycobank: MB 853354

Etymology: *aurantiformosa* = *aurantius* + *formosa*, referring to the species beautiful and orange-colored basidiomata.

Diagnosis: Basidiomata are cream to salmon colored; apices are vivid yellow when young, becoming concolorous with branches at maturity; turn brunnescent where handled; absence of clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Pengta Township, altitude 3100 m, 19 August 2017, P. Zhang 2680 (Holotype, MHHNU 9180, GenBank Acc. No.: ITS =

PP467149, nrLSU = PP493474).

Description: *Basidiomata* 8–10 cm high and 2–4 cm broad, obovate in outline. *Stipe* 1 × 2 cm, single, substantial, pruinose between substrate particles, smooth above, somewhat rugulose, off-white (1A1), brunnescent where handled; flesh off-white (1A1), soft, punky, not gelatinous or slippery, drying firm, easily penetrated, but not friable. *Major branches* 2–3, stout, short, terete. *Branches* in 3–6 ranks,

terete, ascending, light orange (5A5) to salmon (6A4); flesh soft, beautiful peach (7A4) colored; internodes diminishing gradually upward at maturity; axils narrowly rounded below, rounded above. *Apices* finely divided, crowded, cristate, light orange (5A5) colored when young, short-digitate by maturity, retaining salmon (6A4) color. Odor negligible; taste negligible when fresh, bitter when dry.

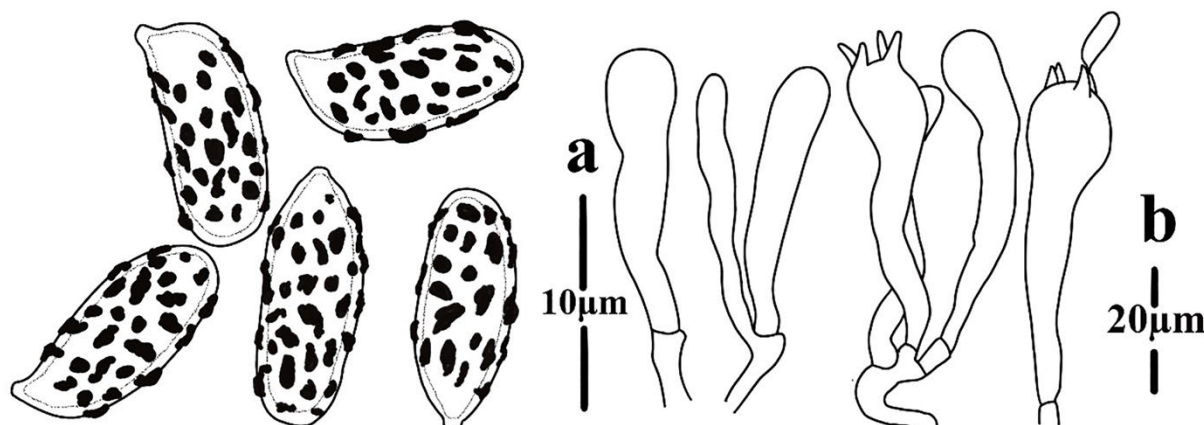


Fig. 95 Microscopic features of *R. aurantiformosa* (MHHNU 9180). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [50/2/2] (9.5–)10.0–13.0 × 4.0(4.2–)5.4(–5.5) μm, $L_m = 11.48$ μm, $l_m = 4.79$ μm, $Q = (2.10–)2.17–2.88(–2.89)$, $Q_m = 2.41 \pm 0.19$, ellipsoid, flattened adaxially, conspicuously roughened in profile; wall up to 0.3 μm thick; hilar appendix not prominent; ornamentation of very complex, narrow, meandering and anastomosing ridges. *Basidia* 55–70 × 9–10 μm, clavate, without clamps; sterigmata (1–2–3–) 4. *Subhymenium* rudimentary; hyphae 1.5–2 μm, without clamps, tightly interwoven. *Tramal hyphae of stipe* 3–13 μm wide, hyaline, gnarled, stiff, freely branched, easily shattered in mounts, thick-walled (wall up to 2 μm thick), interwoven, not agglutinated or adherent; ampulliform septa up to 14 μm broad, thick-walled (wall up to 3 μm thick), with delicate ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* up to 4–12 μm wide, hyaline, thin to thick-walled (wall up to 0.5 μm thick), parallel, without clamps, tightly packed, not agglutinated or adherent; ampulliform inflations not always associated with septa, thick-walled (wall up to 1 μm thick), with delicate, extensive ornamentations; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in mixed forests or in broad-leaved forests. *Basidiomata* occurs in summer and autumn.

Distribution: In southwestern China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Shangri-La City, Pudacuo National Park, Bitahai, in the mixed forest with *Quercus* and *Picea*, altitude 3500 m, 31 August 2022, P. Zhang 4841 (MHHNU 11341); same location, Tianbaotai, in the mixed forest with *Quercus* and *Picea*, altitude 3700 m, 1 September 2022, P. Zhang 4860 (MHHNU 11360), P. Zhang 4861 (MHHNU 11361); Dali, Dali City, Xianyangfeng, in a mixed forest, altitude 2800 m, 12 August 2018, P. Zhang 3375 (MHHNU 9875); Lijiang City, Yulong County, 16 July 2004, Qi Zhao Lj-97 (HKAS 59221). SICHUAN PROVINCE: Ganzi, Kangding City, Pengta

Township, altitude 3100 m, 19 August 2017, P. Zhang 2674 (MHHNU 9174), P. Zhang 2679 (MHHNU 9179).

Commentary: In Zhang (2010), this species was identified as *R. neoformosa* var. *sinensis* R.H. Petersen & M. Zang. However, further collections revealed that its stipes are falsely fasciculate rather than singly stout. Within the *R. neoformosa* species complex, there are two other varieties: var. *neoformosa* and var. *macrospora*. The latter, found in eastern Canada, features larger basidiospores. *Ramaria aurantiformosa* shares many similarities with *R. formosa* in terms of color and basidiomata morphology. However, the presence or absence of clamps easily distinguishes the latter two (Quélet 1888; Corner 1950; Franchi & Marchetti 2021).

Moreover, the species most similar to *R. aurantiformosa* are *R. hilaris* and *R. aureoapicalis*, all of which are salmon to orange colored *Ramaria* found in broad-leaved or mixed forests. They lack clamps, but the basidiospores of the latter two are slightly smaller. While other features are challenging to differentiate, genetic distances in our two-gene molecular phylogenetic analysis (see Fig. 2) confirm them as three distinct species.

71. *Ramaria aurantilinearis* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 c–d and Fig. 96

Mycobank: MB 853355

Etymology: “*aurantilinearis*” = *aurantius* + *linearis*, referring to the basidiomata of the species being orange in color and having slender branches.

Diagnosis: *Basidiomata* are large-sized, dark orange to salmon; stipe slender, fleshy to fibrous; apices are apricot yellow when young, becoming concolorous with branches at maturity; basidia base and hyphae lack clamps; basidiospores are roughened in profile, long and narrow.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus* and *Picea* forest, altitude 3900

m, 6 September 2021, P. Zhang 4256 (Holotype, MHHNU 10756, GenBank Acc. No.: ITS = PP467172, nrLSU = PP493495, *tef1-a* = PP480380).

Description: *Basidiomata* 12 × 10 cm, medium sized to large. *Stipes* up to 5 × 5 cm, single, slender; off-white (1A1) below substrate level, surface pale orange (5A3) to yellowish orange (4A8) upward; surface smooth; nearly without abortive branches; not changing color or weakly brownish orange (6C3) where handled; context of stipe off-white (1A1) when fresh, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* two to several, slender, ascending, terete. *Branches* in 3–7 ranks, slender,

crowded, major branches and upper branches commonly polychotomous; branches salmon (6A4) to melon yellow (5A6); axils mixed narrowly rounded and broadly rounded, mixed U-shaped and U-shaped; internodes all short, lower internodes slightly long; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, off-white (1A1) to pale orange (5A3). *Apices* slender and acute, short and crowded, polychotomous, pale orange (5A3) to apricot yellow (5B6) when young, concolorous with branches when maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

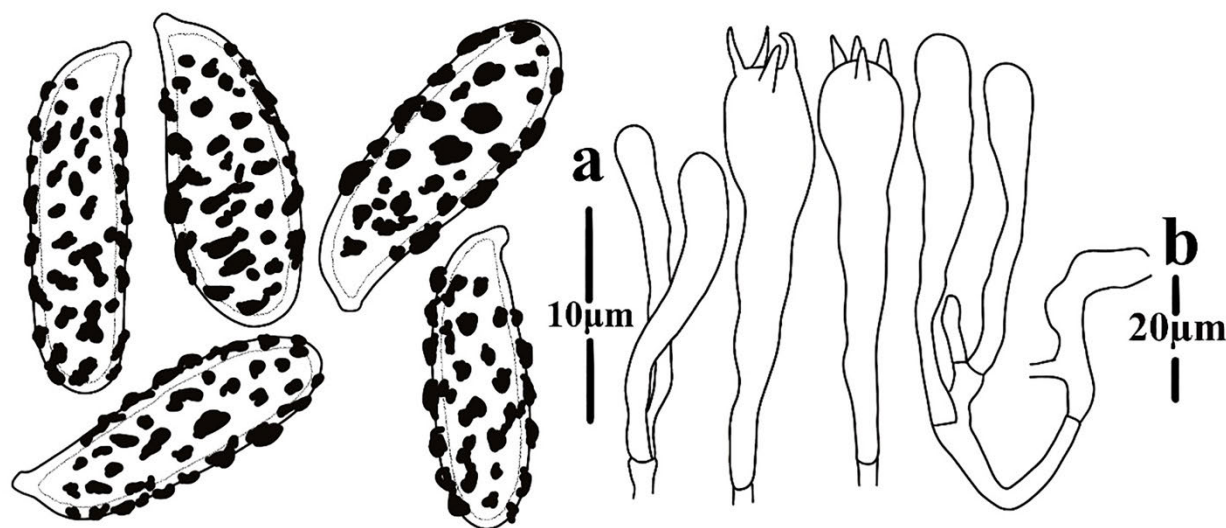


Fig. 96 Microscopic features of *R. aurantilinearis* (MHHNU 10756). a basidiospores; b basidia. Scale bars: a = 10 μm, d = 20 μm.

Basidiospores [60/2/2] (12.6–)13.2–16.5(–19.0) × (4.1–)4.9–6.4(–6.6) μm, $L_m = 14.95$ μm, $l_m = 5.54$ μm, $Q = (2.18\text{--})2.29\text{--}3.17\text{--}(3.81)$, $Q_m = 2.73 \pm 0.32$, subcylindrical to long-ellipsoid; roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. *Basidia* 50–70 × 8–15 μm, clavate, without basal clamps; sterigmata 4, 5–8 μm long, stout, somewhat scattered. *Hymenium* unthickening, 60–80 μm. *Subhymenium* extensive, hyphae, interwoven, 2–5 μm diam, thin-walled, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 5–18 μm wide, loosely parallel, ampulliform inflations up to 18 μm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 18 μm broad; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in mixed forests of *Quercus*, *Picea*, and *Abies*. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus* and *Picea* forest, altitude 3900 m, 6 September 2021, P. Zhang 4286 (MHHNU 10786), P. Zhang 4295 (MHHNU 10795), P. Zhang 4298 (MHHNU 10798), P. Zhang 4315 (MHHNU 10815), P. Zhang 4316 (MHHNU 10816).

Commentary: In the wild, the large basidiomata and slender branches of *R. aurantilinearis* are crucial

characteristics for its identification. Currently, this species has only been collected in the high-altitude regions (3000 – 4000 m above sea level) of Gongga Mountain in China. The small branches are fragile and prone to breaking. Unlike other *Ramaria* species with large basidiomata that typically have stout stipes, *R. aurantilinearis* features densely packed and slender branches. As these basidiomata mature, the internodes elongate, and the number of branches ranks increase, resulting in increasingly massive basidiomata. Under microscopic examination, this species lacks clamps, and its basidiospores are relatively narrow and elongated. The combining of these macroscopic and microscopic features makes *R. aurantilinearis* easily distinguishable among all the yellow/orange *Ramaria* species.

72. *Ramaria aureoapicalis* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 e and Fig. 97

Mycobank: MB 853353

Etymology: "*aureoapicalis*" conveys the characteristic of having golden-yellow apices.

Diagnosis: Basidiomata are salmon colored; apices are vivid yellow when young, becoming concolorous with branches at maturity; turn brunnescent when handled; and absence of clamps.

Type: CHINA, HUNAN PROVINCE: Zhangjiajie City, Sangzhi County, Badagongshan National Nature Reserve, in broad-leaved forest, altitude 1500 m, 14 September 2017, P. Zhang 2828 (Holotype, MHHNU 9328, GenBank Acc. No.: ITS

= PP467146, nrLSU = PP493473, *tef1-α* = PP480363).

Description: *Basidiomata* 6–13 × 3–10 cm, solitary to gregarious. *Stipes* 2.3–5.7 × 0.8–2 cm, single to falsely fasciculate, tapering gradually downward, acute at base; off-white (1A1) below, surface milk white (1A2) to pale yellow (2A3); surface smooth; with abortive branches; changing color to brownish orange (6C3) where handled; context of stipe off-white (1A1) to pale yellow (2A3) when fresh, paler than hymenium, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* 2–several,

ascending, terete. *Branches* in 3–5 ranks, major branches and upper branches mostly dichotomous; branches whitish orange (5A2) to cream (4A3); axils narrowly rounded, U-shaped or V-shaped; internodes diminishing gradually at maturity, lower internodes long; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, pastel yellow (2A4) to pale orange (5A3). *Apices* acute and slender, dichotomous, vivid yellow (2A4) when young, concolorous with branches by maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

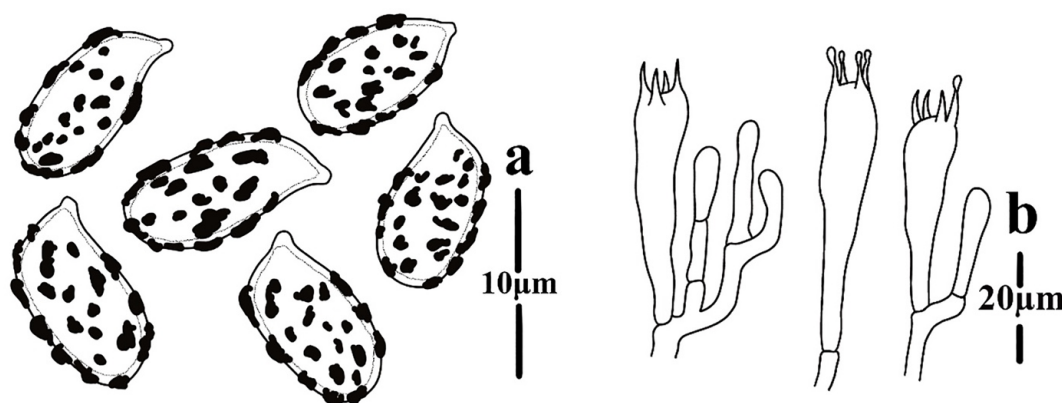


Fig. 97 Microscopic features of *R. aureoapicalis* (MHHNU 9328). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [60/2/2] (8.0–)9.0–13.0(–14.0) × 4.0–6.0(–7.0) μm, $L_m = 10.23$ μm, $l_m = 4.75$ μm, $Q = 1.67$ –2.75(–3.00), $Q_m = 2.17 \pm 0.34$, subcylindrical to long-ellipsoid; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. *Basidia* 40–73 × 8–12 μm, clavate, without basal clamps; sterigmata 4, 4–5 μm long, stout and straight, somewhat scattered. *Hymenium* unthickening, 60–80 μm. *Subhymenium* extensive, hyphae, interwoven, 2–5 μm diam, thin-walled, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 5–18 μm wide, loosely parallel, ampulliform inflations up to 20 μm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 20 μm broad; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved forests. *Basidiomata* occurs in summer and autumn.

Distribution: In central China (Hunan).

Additional materials examined: CHINA, HUNAN PROVINCE: Chenzhou City, Rucheng County, Daping Town, Jiulongjiang National Forest Park, in broad-leaved forest, altitude 100 m, 2 October 2020, P. Zhang 4066 (MHHNU 10566); Zhangjiajie City, Sangzhi County, Badagongshan National Nature Reserve, in the mixed forest, altitude 1400 m, 15 September 2020, Zuo H. Chen 32483 (MHHNU 32483); same location, in broad-leaved forest, altitude 1000 m, 17 September 2019, P. Zhang 3765 (MHHNU 10265).

Commentary: *Ramaria aureoapicalis* bears a striking resemblance to both *R. hilaris* and *R. aurantiformosa*. All three species exhibit salmon to orange-yellow basidiomata with bright yellow apices when young, lack clamps, and show only slight difference in basidiospores size. Our two-gene phylogenetic analysis also indicates a very close genetic relationship among these species. While they all thrive in broad-leaved forests or mixed coniferous-broadleaved

forests, *R. aurantiformosa* is typically found in the southwestern region of China, *R. hilaris* in eastern China, and *R. aureoapicalis* in central China.

73. *Ramaria aureolinearis* P. Zhang & J. Zhong, sp. nov. Fig. 28 f and Fig. 98

Mycobank: MB 853362

Etymology: “*aureolinearis*” indicates that the species is golden-yellow in color and has slender branches.

Diagnosis: Basidiomata are gold yellow to pale orange; absence of clamps; branches are slender.

Type: CHINA, JILIN PROVINCE: Tonghua City, Baijifeng Forest Park, in mixed forests dominated by *Acer*, *Quercus* and *Pinus*, altitude 800 m, 28 Aug. 2020, P. Zhang 4033 (Holotype, MHHNU 10533, GenBank Acc. No.: ITS = PP467166, nrLSU = PP493489, *tef1-α* = PP480375).

Description: *Basidiomata* 14 × 10 cm, medium sized to large. *Stipes* up to 4 × 2 cm, stingle to falsely fasciculate, tapering gradually downward; off-white (1A1) below substrate level, surface pale yellow (2A3) to cream (4A3) upward; surface smooth; with abortive branches; changing color to weakly lemon yellow (3B8) to brownish orange (6C3) where handled; context of stipe off-white (1A1) when fresh, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* several, ascending, hardly terete. *Branches* in 3–5 ranks, slender, major branches commonly polychotomous and upper branches mostly dichotomous; branches salmon (6A4) to melon yellow (5A6); axils mixed narrowly rounded and broadly rounded, mixed U-shaped and U-shaped; internodes diminishing gradually at maturity, lower internodes long; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, off-white (1A1) to pale orange (5A5). *Apices* are slender and acute, crowded, polychotomous, pale orange (5A3) to vivid yellow (2A8), or concolorous with branches. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

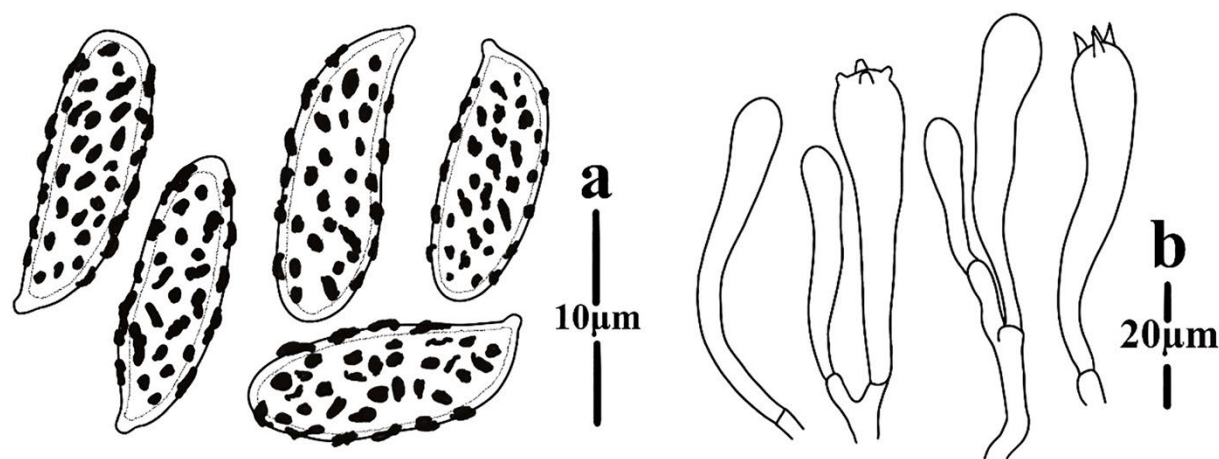


Fig. 98 Microscopic features of *R. aureolinearis* (MHHNU 10533). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Basidiospores [60/2/2] (9.7–)11.4–13.2(–13.7) × (3.3–)3.5–4.9(–5.1) µm, $L_m = 11.68$ µm, $l_m = 4.13$ µm, $Q = (2.37\text{--})2.44\text{--}3.34\text{--}(3.41)$, $Q_m = 2.84 \pm 0.28$, subcylindrical to long-ellipsoid; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. **Basidia** 45–55 × 7–12 µm, clavate, without basal clamps; sterigmata 4, 2–5 µm long, stout, short and straight, somewhat scattered. **Hymenium** unthickening, 50–60 µm. **Subhymenium** extensive, hyphae, interwoven, 2–5 µm diam, thin-walled, without clamps. **Contextual hyphae**: Tramal hyphae of stipe 5–18 µm wide, loosely parallel, ampulliform inflations up to 20 µm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 20 µm broad; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved and coniferous mixed forests. Basidiomata occurs in summer and autumn.

Distribution: In northeast China (Jilin).

Additional materials examined: CHINA, JILIN PROVINCE: Tonghua City, Baijifeng Forest Park, in mixed forests dominated by *Acer*, *Quercus* and *Pinus*, altitude 800 m, 28

Aug. 2020, P. Zhang 4032 (MHHNU 10532).

Commentary: *Ramaria aureolinearis* bears resemblance to *R. aurea* and *R. albidoflava* Schild. Compared to *R. aurea* (basidiospore 10.9 × 4.7 µm; Franchi & Marchetti 2021), both species have orange color in their basidiomata, but *R. aureolinearis* has slightly larger basidiospores and more slender branches. Compared to *R. albidoflava* (= *R. subtilis* var. *crassispota*), the latter has slightly larger basidiospores (12.7 × 5.4 µm; Franchi & Marchetti 2021). However, basidiospores sizes in the genus *Ramaria* can vary during different stages of basidiomata development, so it cannot be used as the sole distinguishing feature. Additionally, while *R. aureolinearis* has orange to salmon-colored basidiomata, *R. albidoflava* exhibits a light-yellow color. Our two-gene molecular phylogenetic analysis supports these three distinct species.

74. *Ramaria brunnescentiflava* P. Zhang & J. Zhong, sp. nov. Fig. 28 g and Fig. 99

Mycobank: MB 853352

Etymology: *brunnescentiflava* = *brunnescens* + *flava*, indicating that the species exhibits a brown coloration in mature basidiomata.

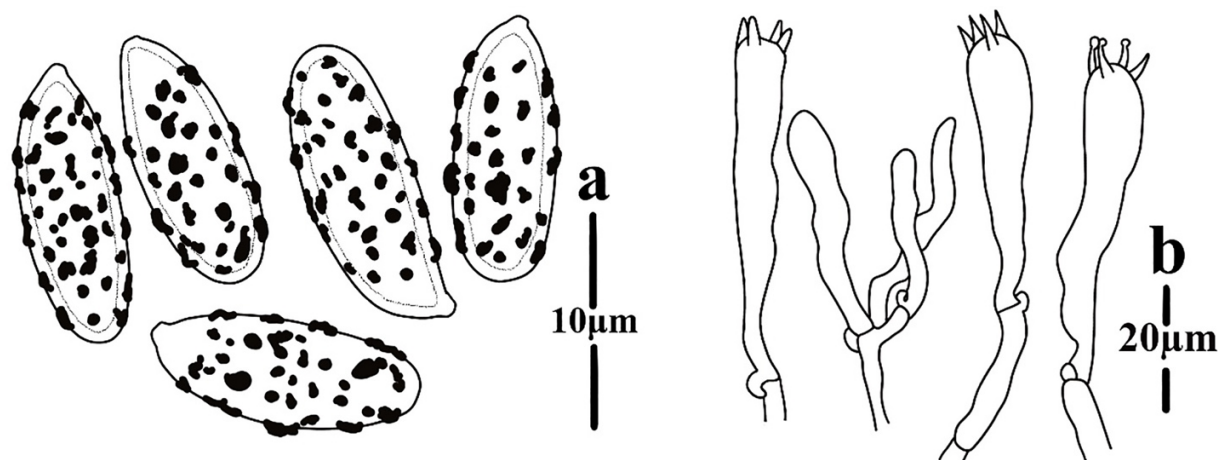


Fig. 99 Microscopic features of *R. brunnescentiflava* (MHHNU 9290). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Diagnosis: Basidiomata are yellow when young, becoming salmon with brownish tones at maturity; stipe is fasciculate or with a very small point of union at the base, acute at the base, and gelatinous; apices are vivid yellow when young, becoming concolorous with branches at maturity; basidia base and hyphae have clamps; changes color to lemon yellow when injured.

Type: CHINA, YUNNAN PROVINCE: Lijiang, Yulong County, Yulong Snow Mountain, altitude 3700 m, 27 July 2017, P. Zhang 2790 (Holotype, MHHNU 9290, GenBank Acc. No.: ITS = PP467177, nrLSU = PP493499, *tef1-a* = PP480384).

Description: *Basidiomata* 11 × 8–10 cm, medium sized. *Stipes* up to 1 × 2 cm, fasciculate or with a very small point of union at the base, tapering sharply downward to an acute base; off-white (1A1) below substrate level, surface pale yellow (2A3) to salmon (6A4) upward; surface smooth; without abortive branches; changing color to lemon yellow (3C8) where handled; context of stipe ivory white (4B3) to grayish orange (6B5) when fresh, gelatinous, difficult to penetrate, cartilaginous. *Major branches* 2–4, slender, ascending, terete. *Branches* in 3–5 ranks, crowded, major branches and upper branches commonly polychotomous; branches salmon (6A4) to melon yellow (5A6); axils mixed broadly rounded, U-shaped; internodes length ratio diminishing gradually at maturity when young, all short by maturity; context of main branches and upper branches gelatinous, ivory white (4B3) to butter yellow (4A5). *Apices* slender and acute when young, broadly rounded when maturity, short digitate, vivid yellow (2A8) when young, concolorous with branches when maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2] (10.0–)10.8–14.8(–15.7) × 3.9–5.2(–5.3) μm , $L_m = 12.52 \mu\text{m}$, $l_m = 4.54 \mu\text{m}$, $Q = (2.23\text{--})2.38\text{--}3.17(3.48)$, $Q_m = 2.77 \pm 0.27$, subcylindrical to long-ellipsoid; roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. *Basidia* 45–65 × 7–10 μm , clavate, with basal clamps; sterigmata 4, 2–5 μm long, stout and short. *Hymenium* unthickening, 60–80 μm . *Subhymenium* extensive, hyphae, interwoven, 2–5 μm diam, thin-walled, with clamps. *Contextual hyphae*: Tramal hyphae of stipe 5–10 μm wide, tightly interwoven, ampulliform inflations not observed; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, tightly interwoven, ampulliform inflations not observed; with clamps; gloeoplereous hyphae not observed.

Ecology: Solitary or gregarious on soil in *Picea* and *Abies* forests, or in mixed forests. Basidiomata occurs in summer

and autumn.

Distribution: In southwest China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, Yulong County, Yulong Snow Mountain, altitude 3700 m, 27 July 2017, P. Zhang 2784 (MHHNU 9284), P. Zhang 2786 (MHHNU 9286). SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Township, Sewurong II Village, in a forest with *Quercus*, altitude 3700 m, 21 August 2017, P. Zhang 2791 (MHHNU 9291).

Commentary: *Ramaria brunnescentiflava* occupies a unique position in the two-gene phylogenetic analysis, distinguishing it as a distinct species. Mature basidiomata of *R. brunnescentiflava* are salmon-colored with brownish tones, and their stipes are compound-connate at the base. This species exhibits a characteristic of turning lemon yellow upon injury and is identified by the presence of prominent clamps. It shares a close affinity with a specimen labeled MF80513 collected in the southern United States, both displaying yellow orange basidiomata and gelatinous, falsely fasciculate stipes. Additionally, *R. brunnescentiflava* is closely related to *R. cistophila* P.P. Daniëls & M.P. Martín (10.9 × 4.7 μm , Daniëls PP et al. 2017) collected in Spain under *Cistus ladanifer*, which also has salmon-colored basidiomata but lacks clamps, furthermore, the basidiospores of *R. brunnescentiflava* are larger.

75. *Ramaria conferta* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 17 (2024) Fig. 28 w–x and Fig. 100

Description: *Basidiomata* 10 × 7 cm, medium sized. *Stipes* up to 3 × 3.5 cm, single, terete, rounded at base; off-white below substrate level, surface pale orange to yellowish orange upward; surface smooth; nearly without abortive branches; not changing color or weakly brownish orange where handled; context of stipe off-white when fresh, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* two to several, slender, ascending, terete. *Branches* in 3–7 ranks, slender, crowded, major branches and upper branches commonly polychotomous; branches salmon to melon yellow; axils mixed narrowly rounded and broadly rounded, mixed U-shaped and U-shaped; internodes all short, lower internodes slightly long; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, off-white to pale orange. *Apices* slender and acute, short and crowded, polychotomous, concolorous with branches when young, sometimes darker to brown when maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.



Fig. 100 Basidiospores of *R. conferta* (MHHNU 10088). Scale bar: a = 10 μm .

Basidiospores [60/2/2] (10.1–)10.7–14.3(–14.8) × (4.0–)4.3–6.2(–6.5) μm , $L_m = 12.31 \mu\text{m}$, $l_m = 5.24 \mu\text{m}$, $Q = (1.99\text{--})2.03\text{--}2.72(3.06)$, $Q_m = 2.37 \pm 0.23$, subcylindrical to long-ellipsoid; roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. **Basidia** 45–65 × 7–12 μm , clavate, without basal clamps; sterigmata 4, 5–8 μm long, stout, somewhat scattered. **Hymenium** unthickening, 60–80 μm . **Subhymenium** extensive, hyphae, interwoven, 2–5 μm diam, thin-walled, without clamps. **Contextual hyphae**: Tramal hyphae of stipe 5–18 μm wide, loosely parallel, ampulliform inflations up to 18 μm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 18 μm broad; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in *Picea* and *Abies* forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest, north and northwest China (Sichuan, Xinjiang, Shanxi).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in the *Abies* forest, altitude 3500 m, 2 September 2021, P. Zhang 3588 (MHHNU 10088); same city, Waze Township, in *Picea* forest, altitude 3800 m, 1 September 2018, P. Zhang 3567 (MHHNU 10067), P. Zhang 3568 (MHHNU 10068), P. Zhang 3570 (MHHNU 10070); same location, 23 August 2017, P. Zhang 2732 (MHHNU 9232); same city, Mugecuo, in a *Abies* forest, altitude 3500 m, 21 August 2017, P. Zhang 2707 (MHHNU 9207). XINJIANG UYGUR AUTONOMOUS REGION: Urumqi City, Urumqi County, Nan Mountain, in *Picea* and *Abies* forest., altitude 2000 m, 24 August 2013, P. Zhang 1335 (MHHNU 7835). GANSU PROVINCE: Lanzhou City, Yuzhong County, Xinglong Mountain Nature Reserve, Dong Mountain, in a coniferous and broad-leaved mixed forest, altitude 2300 m, 7 August 2019, P. Zhang 3705 (MHHNU 10205).

Commentary: The distribution of *R. conferta* is relatively extensive, ranging from the southwestern to the northwestern of China. It prefers to grow under *Picea* trees and shares a close phylogenetic relationship with the *R. robustibrunnea* and *R. aurantilinearis*. These three species exhibit similar-colored basidiomata and lack clamps. They are commonly found in forests with *Picea* trees. However, compared to the *R. robustibrunnea* (11.01 × 4.69 μm), *R. conferta* has a slender stipe, and its basidiospores are larger. In comparison to *R. aurantilinearis* (14.95 × 5.54 μm), both the basidiospores and fruiting body sizes of *R. conferta* are smaller.

76. **Ramaria cyanophila** L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 19 (2024)

Original description in Li et al. (2024).

77. **Ramaria distinctissima** R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 376, 1989. Fig. 28 h and Fig. 101

Description: **Basidiomata** 5–7 cm high and 3–7 cm broad, obpyriforme in outline. **Stipes** up to 2 × 1–2 cm, tapering gradually to the acute, often rooting at base, tomentose at base, smooth upward, without abortive branches, off-white where protected, easily brunnescent around substrate bruises but not on handling; flesh white, solid, moist, drying brittle, penetrated with difficulty but not to impenetrable. **Major branches** 2–4, terete, ascending, concolorous to stipe below, concolorous to branches above. **Branches** in 3–6 ranks, terete, ascending, pastel yellow orange or yellow below, upward pasteur orange; internodes diminishing gradually upwards at maturity; axils narrowly rounder below, rounded above; flesh somewhat yellow than hymenium, white inward, drying brittle, friable. **Apices** double-dichotomous when young, elongating to short-digitate by maturity, rich golden orange to yellowish orange. Odor negligible or faintly fresh; taste negligible.



Fig. 101 Basidiospore of *R. distinctissima* (MHHNU 9980). Scale bars: a = 10 μm .

Basidiospores [40/2/2] (12.0)12.7–15.6(–16.1) × (4.4–)4.8–6.0(–6.2) μm , $L_m = 14.20 \mu\text{m}$, $l_m = 5.22 \mu\text{m}$, $Q = (2.16\text{--})2.36\text{--}3.04(3.29)$, $Q_m = 2.74 \pm 0.22$, long-ellipsoid, conspicuously roughened in profile; wall up to 0.3 μm thick; hilar appendix gradual, not prominent, with apparent struma; ornamentation of prominent, discrete, low warts and short meandering ridges. **Basidia** 85–95 × 10–12 μm , clavate, clamped, in tight cymes; weakly cyanophilous; sterigmata 4, up to 6 μm long, spindly, straight. **Subhymenium** rudimentary; pseudo-parenchymatous; hyphae 1.5–3 μm , conspicuously clamped. **Hymenium** thickening; **Tramal hyphae** of stipe 4–15 μm wide,

hyaline, thin to thick-walled (wall up to 0.3 μm thick), interwoven, hyaline, thin to thick-walled (wall up to 0.5 μm thick), without clamps, interwoven, not agglutinated or adherent, thick-walled (wall up to 1.5 μm thick); usually without clamps, tightly packed; ampulliform swelling up to 15 μm broad, often not associated with septa, not unusually thick-walled, with extensive ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae** of upper branches up to 4–18 μm wide, inflated especially inward, hyaline, thin- to thick-walled (wall up to 0.5 μm thick), almost always without clamps, parallel, not agglutinated or adherent; cells cigar-

shaped; ampulliform swelling and gloeoplerous not observed.

Ecology: Solitary or gregarious on soil in *Picea* and *Abies* forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Yunnan, Sichuan, Xizang).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang City, Yulong County, 16 July 2004, Qi Zhao Lj-97 (HKAS 59221). SICHUAN PROVINCE: Ganzi, Jiulong County, northern Tanggu Township, Wuxuhai, in *Picea* and *Abies* forest, altitude 4100 m, 19 August 2023, Zuo H. Chen 34086 (MHHNU 34086); Shangri-La City, Pudacuo National Park, Tianbaotai, in the mixed forest with *Quercus* and *Picea*, altitude 3700 m, 1 September 2022, P. Zhang 4866 (MHHNU 11366). XIZANG AUTONOMOUS REGION: Changdu City, Leiwuqi County, altitude 3900 m, 10 August 2004, Zhu L. Yang 4356 (HKAS 45735); same city, Basu County, Ranwu Lake, in *Picea* and *Abies* forest, altitude 3,900 m, 22 August 2018, P. Zhang 3480 (MHHNU 9980).

Commentary: The main features of *R. distinctissima* include: 1) salmon to orange-colored branches of the basidiomata; 2) stipe tapering gradually to an acute point, fleshy to fibrous, and concolorous with the branches; 3) absence of clamps at the base of basidia and in hyphae; 4) preference for growing in *Picea* and *Abies* forests.

The basidiospores size of *R. distinctissima* is slightly smaller than that of *R. sinolargentii*. The golden-yellow coloration of the upper stipe and lower major branches may result from exposed hymenium due to injury. This species shares similarities with *R. flavicingula* ($12.8 \times 4.8 \mu\text{m}$, Franchi & Marchetti 2021), *R. argentii* ($13.4 \times 4.5 \mu\text{m}$, Marr & Stuntz 1973), and *R. luteoaurantiaca* ($13.0 \times 4.6 \mu\text{m}$, Franchi &

Marchetti 2021). However, its basidiospores are larger than those of the three species.

The virtually indistinguishable *R. distinctissima* var. *americana* (Petersen & Scates 1988) in North America differs from the typical variety in the following characters: 1) the stipe of basidiomata tapers more sharply into an obconic base; 2) tramal hyphae of the upper branches are strictly thin walled; 3) basidia are somewhat wider than those of *R. distinctissima* var. *distinctissima*.

78. *Ramaria ephemeroderma* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 378, 1989. Fig. 28 i and Fig. 102

Description: Basidiomata 13 cm high and 6 cm broad, circular to broadly fusiform in outline. Stipe 3×2 cm, single, falsely fasciculate, lobed or muscled, tapering to a blunt base, spongy when pressed, pruinose between major branches, otherwise smooth, with no abortive branchlets, off-white, not brunnescent; flesh firmly gelatinous, slippery, off-white below, paster orange at junction with major branches. Major branches 3–several, curved-ascending, hardly terete, pallid salmon-pink with some areas rich yellow. Branches terete, in 3–7 ranks, ascending, salmon color; branch surface (hymenium) quickly fading after picking to pale pink or pale salmon pink; branch flesh watery gelatinous, stuffed to hollow, brittle, bright orange remaining so during drying, drying horny, cartilaginous; internodes diminishing gradually upward at maturity; axils lunate to narrowly rounded. Apices fine, delicate, double-dichotomous when young, delicately digitate by maturity, bright yellow. Odor faintly fresh or penetrating; taste negligible.



Fig. 102 Basidiospore of *R. ephemeroderma* (MHHNU 6601). Scale bar: a = 10 μm .

Basidiospores $[72/3/3](10.0\text{--}10.5\text{--}13.3\text{--}(14.0) \times (3.5\text{--}4.0\text{--}5.0\text{--}(5.1) \mu\text{m}$, $L_m = 11.91 \mu\text{m}$, $l_m = 4.47 \mu\text{m}$, $Q = (2.08\text{--}2.29\text{--}3.08\text{--}(3.47)$, $Q_m = 2.67 \pm 0.25$, ellipsoid, flattened adaxially, conspicuously roughened in profile; wall up to $0.2 \mu\text{m}$ thick; hilar appendix blunt, broad, hardly protuberant; ornamentation of large plate-like warts and/or complex, anastomosing ridges. **Basidia** $55\text{--}62 \times 7\text{--}9 \mu\text{m}$, clavate, without clamps, hyaline; sterigmata 4, short, spindly, curved. **Subhymenium** abrupt, rudimentary; hyphae $2\text{--}5 \mu\text{m}$ diam, hyaline, thin walled, without clamps, parallel inward, interwoven to perpendicular outward, not agglutinated or adherent. **Hymenium** thickening. **Tramal hyphae of stipe** $4\text{--}11 \mu\text{m}$ wide, hyaline, thick-walled (wall up to $1 \mu\text{m}$ thick), heavily agglutinated, without clamps, parallel; gelatin insoluble in KOH, often separating individual hyphae by $15 \mu\text{m}$ or more; ampulliform swellings up to $13 \mu\text{m}$ broad, not unusually thick-walled, with extensive, coarse ornamentation; gloeocarpous hyphae not observed. **Tramal hyphae of upper branches** 3–

$11\text{--}(20) \mu\text{m}$ diam, hyaline, without clamps, thin-walled, agglutinated to adherent, strictly parallel, tightly packed, less agglutinated outward; ampulliform swellings not observed.

Ecology: Solitary or gregarious on soil in *Picea*, *Abies* and *Quercus* forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Yunnan, Sichuan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, Yulong County, Yulong Snow Mountain, altitude 3700 m, 27 July 2017, P. Zhang 2799 (MHHNU 9299); Baoshan City, Longling County, Tianning Township, altitude 2100 m, 28 August 2002, Zhu L. Yang 3330 (HKAS41399); Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 2 August 2001, P. Zhang 101 (MHHNU 6601). SICHUAN PROVINCE: Ganzi, Jiulong County, Gongga Mountain National Nature Reserve, in *Picea* and *Abies* forest, altitude 4000 m, 18 August 2023, Zuo H. Chen 34066 (MHHNU 34066).

Commentary: The main features of *R. ephemeroderma*

include: 1) salmon colored hymenium that quickly fades to almost white after the basidiomata are picked, revealing the carrot-orange, gelatinous flesh beneath; 2) absence clamps; 3) wide, conspicuously guttulate basidiospores; and 4) an abrupt transition from gelatinous flesh to free sub-hymenium and loosely arranged hymenium (difficult to observe).

The taxa within *Ramaria* with gelatinous basidiomata flesh are numerous and do not seem to form a natural alliance. Among these, several exhibit salmon branches and yellow apices of varying color intensities. *Ramaria gelatiniaurantia* var. *gelatiniaurantia* Marr & Stuntz from western North America display white flesh, fasciculate stipes, and yellow lower branches (Marr & Stuntz 1973). *Ramaria ochraceo-salmonicolor* (Ciel.) Corner from Australia (Corner 1950), and *R. gelatiniaurantia* var. *gelatiniaurantia* Marr & Stuntz (1973) from western North America produce less intense coloration and narrower basidiospores than *R. ephemero-derma*. *Ramaria subtilis* (Coker) Schild (1982) from eastern North America shows white flesh with locally adherent hyphae (not

gelatinous). Finally, *R. flavigelatinosa* var. *megalospore* Marr & Stuntz (1973), found across northern North America, exhibits mottled white flesh and longer basidiospores than *R. ephemero-derma*.

79. *Ramaria hiliaris* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 382, 1989. Fig. 28 j and Fig. 103

Description: *Basidiomata* 12 cm high and 4.5 cm broad, elongate obpyriform in outline. *Stipe* 5 × 2 cm, tapering downward evenly to narrowly rounded base, rooting, with 1–2 abortive branchlets high on stipe, smooth, very clean, off-white below, yellow above; not brunnescent; flesh off-white, mottled or marbled, slippery when cut. *Major branches* 2–3, terete, ascending, bright yellow. *Branches* in 3–5 ranks, terete, curved, ascending, somewhat secund, fleshy golden yellow; flesh paler than hymenium, solid, slippery, brittle; internodes long, diminishing gradually upward; axils rounded throughout. *Apices* short-digitate, somewhat divergent, bright golden yellow. Odor and taste are negligible.

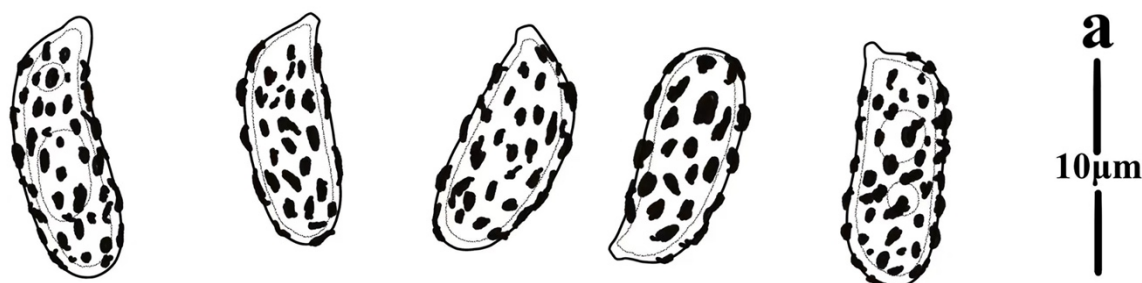


Fig. 103 Basidiospore of *R. hiliaris* (MHKMU Yang409). Scale bar: a = 10 µm.

Basidiospores [60/2/2] (8.8–)8.9–11.9(–12.6) × (3.9–)4.1–5.2(–5.4) µm, $L_m = 10.39$ µm, $l_m = 4.64$ µm, $Q = (1.78)1.96$ –2.67(–2.73), $Q_m = 2.25 \pm 0.25$, ellipsoid, flattened adaxially, coarsely undulate in profile; wall up to 0.2 µm thick; hilar appendix prominent, truncate; ornamentation of large, flat warts and anastomosing ridges. **Basidia** 55–65 × 8–9 µm, clavate, without clamps; sterigmata 4, slender, curved. **Subhymenium** extensive; pseudo-parenchymatous. **Hymenium** thickening; **Tramal hyphae of stipe** 3–10 µm wide, hyaline, without clamps, thin-to thick-walled (wall up to 0.5 µm thick); tightly packed, parallel, agglutinated, with occasional lacunae of agglutinating material; ampulliform inflations at septa, up to 15 µm broad, not unusually thick-walled, extensively ornamented; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** up to 3–7 µm wide, hyaline, without clamps, thin walled, strictly parallel, tightly packed, adherent to semi-agglutinated, with frequent lacunae of agglutinating substance; ampulliform inflations at septa, up to 14 µm broad, thick walled (wall up to 0.5 µm thick), delicately ornamented only at septum; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in mixed forests or in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest and east China (Yunnan, Zhejiang).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Wuding County, Gaoqiao Township, in broad-leaved forest with Fagaceae and Pinaceae, altitude

2555 m, 21 August 2016, Li P. Tang Yang409 (MHKMU Yang409). ZHEJIANG PROVINCE: Wenzhou City, Taishun County, Wuyanling National Nature Reserve, Yangxi, in broad-leaved forest, altitude 514 m, 28 August 2021, P. Zhang 4425 (MHHNU 10925).

Commentary: Petersen originally cited HKAS 20046 as the holotype of *R. hiliaris*. However, our phylogenetic analyses and examination of the specimen indicate that HKAS 20046 was incorrectly identified and actually represents *R. lineariflava* (see the discussion under *R. lineariflava* for details).

The marbled, slippery flesh of *R. hiliaris* evident under microscopic examination, with an abundant agglutinating substance that forms gelatinous lacunae in flesh tissues. Even when softened in 2% KOH (in dried material), the substance remains rubbery and resists compression on mounts. In contrast, *R. didtinctissima* and *R. linearoides* resemble *R. hiliaris* in stature but have non-slippery flesh with clamps (Petersen & Zang 1989). *Ramaria linearis* shares similar stature and coloration with *R. hiliaris*, but its flesh is not gelatinous, and its basidiospores are larger (11.6 × 4.9 µm, Petersen & Zang 1989).

80. *Ramaria hypogaeoides* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 k and Fig. 104

Mycobank: MB 853359

Etymology: “*hypogaeoides*” indicates that the species is similar to *R. hypogae*.

Diagnosis: Basidiomata are medium sizedmedium sized

to large, salmon to yellow and orange in color; basidiospores are long and broadly sized; hyphal and basidia lack clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding County, Mugecuo, in forest dominated by *Abies* and

Pinaceae, altitude 3800 m, 21 August 2017, P. Zhang 2711 (Holotype, MHHNU 9211, GenBank Acc. No.: ITS = PP467153, nrLSU = PP493478, *tef1-a* = PP480366).

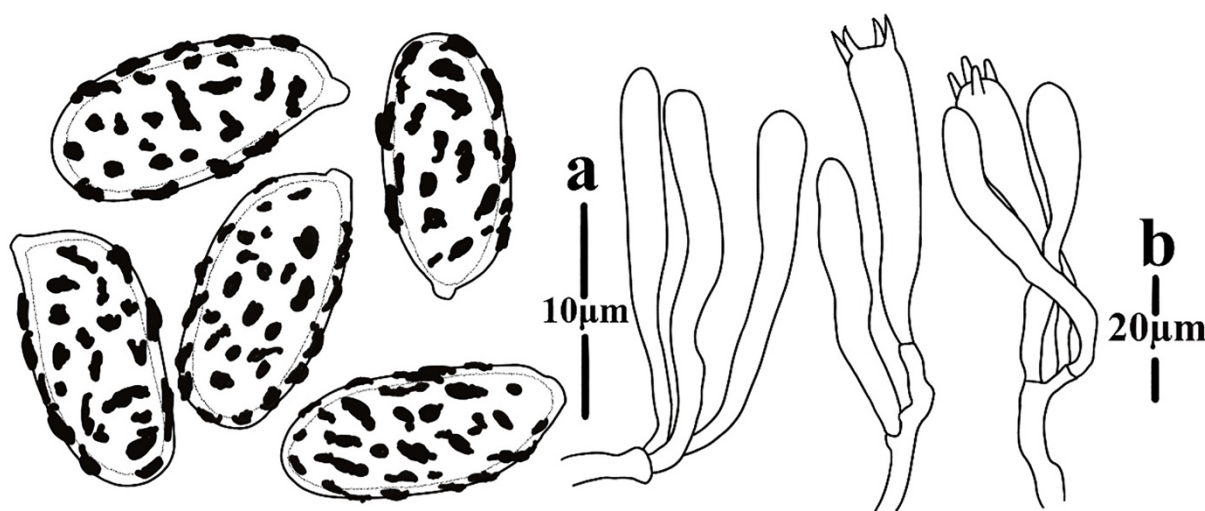


Fig. 104 Microscopic features of *R. hypogaeoides* (MHHNU 9211). a basidiospores; b basidia. Scale bars: a = 10 μ m, b = 20 μ m.

Description: *Basidiomata* 15 $\times$ 9 cm, solitary to gregarious. *Stipes* nearly absent, commonly compound by several single stipes, tapering gradually downward, acute at base; off-white (1A1) below substrate level, surface pale yellow (2A3); surface smooth; with abortive branches; not changing color to weakly watery brunnescent where handled; context of stipe off-white (1A1) to pale yellow (2A3) when fresh, paler than hymenium, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* several, ascending, hardly terete. *Branches* in 3–5 ranks, major branches commonly polychotomous and upper branches mostly dichotomous; branches salmon (6A4) to melon yellow (5A6); axils narrowly rounded, mostly V-shaped; internodes diminishing gradually at maturity, terete; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, pastel yellow (2A4) to pale orange (5A3). *Apices* acute and slender, molar-like when young, digitate at maturity, polychotomous, concolorous with branches or slightly dark than branches. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [62/2/2] (10.4–)11.3–14.5(–15.6) $\times$ 5.1–6.6(–6.8) μ m, L_m = 13.12 μ m, l_m = 5.77 μ m, Q = (1.67–)1.97–2.66(–2.82), Q_m = 2.28 $\pm$ 0.24, subcylindrical to long-ellipsoid; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. *Basidia* 50–70 $\times$ 6–10 μ m, clavate, without basal clamps; sterigmata 4, 3–6 μ m long, stout and straight, somewhat scattered. *Hymenium* unthickening, 60–70 μ m. *Subhymenium* extensive, hyphae, interwoven, 2–5 μ m diam, thin-walled, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 5–18 μ m wide, loosely parallel, ampulliform inflations up to 20 μ m broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 20 μ m broad; without clamps; gloeoplereous hyphae not observed.

Ecology: Solitary or gregarious on soil in *Picea*, *Abies* and *Quercus* forests. *Basidiomata* occurs in summer and autumn.

Distribution: In southwest China (Sichuan).

Additional material examined: CHINA, YUNNAN PROVINCE: Shangri-La City, altitude 3897 m, on 8 August 2016, Jian W. Liu 501 (MHHNU 11637).

Commentary: *Ramaria hypogaeoides* share similarities with *R. hypogaea* described by Wu (1987). Both species exhibit a whitish color in the underground unexposed parts and above-ground structures that branches directly in a clustered manner. Their *basidiomata* size exceeds 10 cm high, with colors range from yellowish orange to salmon, and neither species shows clamps. However, significant differences exist. *Ramaria hypogaea* has smaller basidiospores (6.2–9.2 $\times$ 4.6–6.2 μ m, L_m = 7.9 μ m, l_m = 5.2 μ m, Q_m = 1.52) and slender underground branches. It remains unclear whether these growth characteristics differences are inherent or due to random factors.

In fact, *R. hypogaeoides* shares a close phylogenetic relationship with *R. distinctissima* and *R. sinolargentii* in the southwestern region of China, as well as *R. longiaurantia*, all belonging to the group with warted basidiospores in orange/yellow/salmon hues. However, its basidiospores are relatively smaller and wider than those of the other three species.

81. *Ramaria linearis* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 387, 1989. Fig. 28 I and Fig. 105

Description: *Basidiomata* 14 cm high and 6 cm broad, linear, elongate obpyriform in outline. *Stipes* up to 1 $\times$ 1.5 cm, small, tapered to an acute base, white, smooth, often with abortive branchlets, reluctantly brunnescent on handling; flesh white, solid, moist but not slippery, often mottled hydrophanous; abortive branchlets yellow to pastel orange; surface of stipe and lower branches becoming grey upon drying. *Major branches* several, strictly ascending, terete, clear yellow. *Branches* in 4–7 ranks, terete, strict, orange, pastel orange to pastel salmon, fading in age to "ochraceous buff"; internodes somewhat long throughout, diminishing gradually upward at maturity; axils narrowly rounded below,

rounded above; flesh solid, sometimes slippery when cut, orange. Apices fine, delicate, knobby-digitate by maturity, somewhat divaricate, golden yellow to pastel orange. Odor negligible; taste negligible or faintly fungoid.



Fig. 105 Basidiospore of *R. linearis* (MHHNU 10003). Scale bars: a = 10 µm.

Basidiospores [50/2/2] (11.2–)11.8–15.0 × (4.8–)5.0–5.8(–6.0) µm, $L_m = 13.56$ µm, $l_m = 5.14$ µm, $Q = (2.18–)2.24–2.88(–3.13)$, $Q_m = 2.63 \pm 0.23$, narrowly ellipsoid, conspicuously roughened in profile; wall up to 0.2 µm thick; hilar appendix gradual, prominent, almost perpendicular to basidiospores axis; ornamentation of prominent elongate warts and anastomosing, meandering ridges. **Basidia** 57–65 × 9–11 µm, clavate, without clamps; moderately cyanophilous; sterigmata 4, short, spindly, straight to curved. **Hymenium** thickening. **Subhymenium** rudimentary; hyphae 1.5–2.5 µm, tightly packed, interwoven, without clamps. **Tramal hyphae of stipe** 4–12 µm wide, hyaline, thick-walled (wall up to 0.5 µm thick), without clamps, tightly interwoven, not agglutinated or adherent; ampulliform swelling rare, not associated with septa, not unusually thick-walled, with coarse, extensive stalactitiform ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** up to 4–11 µm wide, hyaline, without clamps, thin-walled, parallel, tightly packed, free to locally adherent; ampulliform swellings not observed; gloeoplerous hyphae sometimes common.

Ecology: In mixed forests dominated by *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known in southwestern and central China (Yunnan, Xizang, Hubei).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, brought from mushroom market, 30 August 1986, Petersen 47301 (isotype, HKAS 17729). XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3503 (MHHNU 10003), P. Zhang 3505 (MHHNU 10005), P. Zhang 3506 (MHHNU 10006), P. Zhang 3518 (MHHNU 10018). HUBEI PROVINCE: Enshi, Hefeng County, Mulinzi Nature Reserve, broad-leaved forest, altitude 1300 m, 24 August 2019, Zuo H. Chen 31679 (MHHNU 31679); Yichang City, Shennongjia National Nature Reserve, in mixed forests dominated by *Quercus*, altitude 1600 m, 4 September 2002, P. Zhang 251 (MHHNU 6751), P. Zhang 255 (MHHNU 6755).

Commentary: The main features of this species include: basidiomata with a linear stature, featuring small but single stipes that superficially appear fasciculate; lower branches are golden yellow, while upper branches exhibit salmon or orange hues with golden yellow apices; basidia lack clamps; basidiospores are prominently roughened. When collected by Petersen, this species was initially thought to resemble *R.*

leptoformosa Marr & Stuntz, which shares a linear stature and salmon branches with yellow apices. However, *R. leptoformosa* differs by having clamped basidia and lacks the distinct color contrast between lower major branches and branches.

82. ***Ramaria longiaurantia*** P. Zhang & J. Zhong, **sp. nov.** Fig. 28 m and Fig. 106

Mycobank: MB 853358

Etymology: “*longiaurantia*” = *longus* + *aurantia*, indicating that the species has orange-colored basidiomata and long basidiospores.

Diagnosis: Basidiomata are medium sizedmedium sized to large, salmon to orange; average basidiospores size is greater than 16 µm; hyphal and basidia have clamps.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 6 September 2021, P. Zhang 4306 (Holotype, MHHNU 10806, GenBank Acc. No.: ITS = PP467155, nrLSU = PP493480, *tef1-α* = PP480368).

Description: **Basidiomata** 11 × 10 cm, solitary to gregarious. **Stipes** up to 2.5 × 3 cm, to compound-connate, rounded base; off-white (1A1) below substrate level, surface pale yellow (2A3) to salmon (6A4) upward; surface smooth; without abortive branches; not changing color to weakly watery brunnescent where handled; context of stipe off-white (1A1) when fresh, paler than hymenium, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. **Major branches** several, ascending, hardly terete. **Branches** in 3–5 ranks, major branches commonly polychotomous and upper branches mostly dichotomous; branches salmon (6A4) to melon yellow (5A6); axils narrowly rounded when young, broadly rounded and mostly U-shaped at maturity; internodes short when young, diminishing gradually at maturity, terete, subparallel upward; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, off-white (1A1) to pale orange (5A5). **Apices** molar-like when young, digitate at maturity, dichotomous, 2–10 mm, concolorous with branches. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [65/2/2] (14.0–)15.2–18.9(–19.0) × (4.5–)4.8–6.3(–6.8) µm, $L_m = 16.08$ µm, $l_m = 5.47$ µm, $Q = (2.47–)2.65–3.28(–3.52)$, $Q_m = 2.96 \pm 0.23$, subcylindrical; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. **Basidia** 50–80 × 8–13 µm, long, clavate, with basal clamps; sterigmata 4, 4–7 µm long, stout and straight, somewhat scattered. **Hymenium** unthickening, 70–85 µm. **Subhymenium** extensive, hyphae, interwoven, 2–5 µm diam, thin-walled, with clamps. **Contextual hyphae:** **Tramal hyphae of stipe** 3–15 µm wide, loosely parallel, ampulliform inflations up to 18 µm broad, with coarse ornamentation; **tramal hyphae of branches** central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 18 µm broad; clamps conspicuously; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in *Picea*, *Abies* and *Quercus* forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 6 September 2021, P. Zhang 4289 (MHHNU 10789),

P. Zhang 4314 (MHHNU 10814); same location, 5 September 2021, P. Zhang 4284 (MHHNU 10784); same city, Jiulong County, northern Tanggu Township, Wuxuhai, in *Picea* and *Abies* forest, altitude 4100 m, 10 August 2021, Zuo H. Chen 33118 (MHHNU 33118).

Commentary: *Ramaria longiaurantia* is currently the species within the genus *Ramaria* in China known for having the largest warted basidiospores. It bears resemblance to *R. distinctissima* and *R. sinolargentii* found in the southwestern

China. However, *R. longiaurantia* is more salmon to orange in overall color, whereas the former tends to be more reddish orange. Unlike *R. sinolargentii*, which often has singly tapering stipes, *R. longiaurantia* typically features aggregated compound stipes, where multiple axes converge at the base. Additionally, the stipes below the substrate are longer and white, contrasting with the lower axils of the stipes above the substrate.

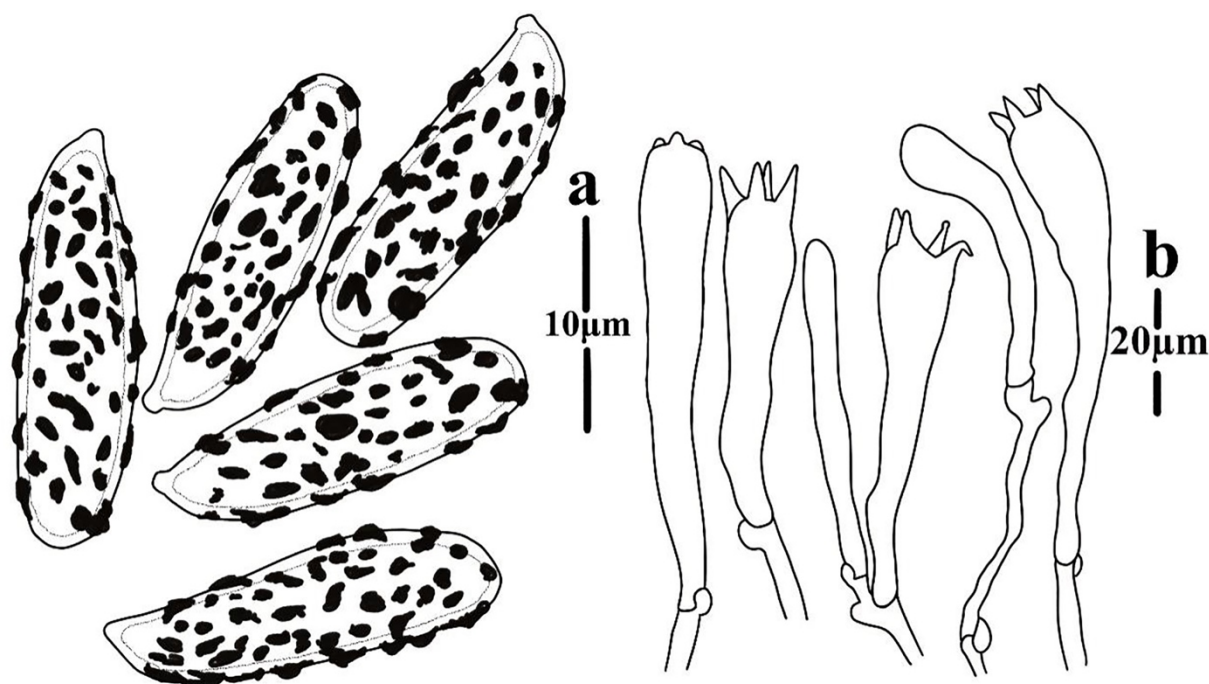


Fig. 106 Microscopic features of *R. longiaurantia* (MHHNU 10806). a basidiospores; b basidia. Scale bars: a = 10 μm, d = 20 μm.

83. ***Ramaria luteoaurantiaca*** Franchi & M. Marchetti, in Marchetti, Index Fungorum 433: 1 (2020) Fig. 28 n and Fig. 107

Description: *Basidiomata* 4.7–6 cm high and 2.5–6.5 cm broad, depressed-obovate in outline. *Stipe* 1.2–2.9 × 1.5–3.3 cm, single, bluntly cylindrical to broadly rounded, smooth, occasionally with 1–2 abortive branchlets, off-white below substrate level, pale yellow to vivid yellow above, not brunescent to weakly watery brunescent where handled; flesh off-white, solid, moist but not gelatinous or slippery

when cut. *Major branches* several, short, terete, concolorous with branches. *Branches* in 3–6 ranks, generally short, terete, elongating only in age, varying from pale yellow to vivid yellow; flesh often somewhat more orange than hymenium; internodes all short until maturity, diminishing gradually upward; axils narrowly rounded to acute when young, rounded at maturity. *Apices* bluntly digitate to molar-like when young, digitate at maturity, varying in color from chrome yellow, with slightly apricot yellow. Odor mildly aromatic; Taste weakly sweet to negligible.



Fig. 107 Basidiospore features of *R. luteoaurantiaca* (MHHNU 10235). Scale bar: a = 10 μm.

Basidiospores [30/1/1] (8.3–)8.5–11.9(–12.1) × (3.1–)3.6–4.9(–5.1) μm, $L_m = 9.72$ μm, $l_m = 4.28$ μm, $Q = (1.92–)2.02–2.76(–2.97)$, $Q_m = 2.30 \pm 0.23$, ellipsoid to subcylindrical,

conspicuously roughened in profile; hilar appendix curved, not prominent; ornamentation of scattered small warts and/or short anastomosing ridges apparently without orientation.

Basidia 50–65 × 8–9 µm, clavate, clamped, tightly interwoven; sterigmata 4, long and slender, curved. *Subhymenium* rudimentary, hyphae 1.5–2.5 µm diam, pseudo-parenchymatous. *Hymenium* thickening: *Tramal hyphae* of stipe 3–14 µm diam, hyaline, thin-to thick-walled, o, clamped, not adherent or agglutinated, tightly interwoven; ampulliform septa up to 15 µm broad, thick-walled, with warts-like ornamentation; gloeoplerous hyphae not observed. *Tramal hyphae* of upper branches up to 3–12 µm diam, hyaline, thin to thick walled, parallel, tight packed, clamped; ampulliform swellings up to 14 µm broad, thick-walled, unornamented; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in *Picea* forests. Basidiomata occurs in summer and autumn.

Distribution: In northwest China (Xinjiang); Europe (Italy).

Additional material examined: Ili, Tekes County, Qiongkushitai, in a *Picea* forest, altitude 2000, 21 August 2019, Ping Zhang 3735 (MHHNU 10235).

Commentary: *Ramaria luteoaurantiaca* bears a striking resemblance to *R. flavicingula* R.H. Petersen in European and *R. largentii* Marr & Stuntz in American. They are nearly indistinguishable in appearance, all featuring yellow to orange-colored basidiomata and growing in coniferous forests. The primary differences between *R. luteoaurantiaca* and *R. flavicingula* may include occasional abortive

branchlets on the stipes and slightly smaller basidiospores (12.8 × 4.8 µm, Franchi & Marchetti 2021). In contrast, *R. largentii* is characterized by larger basidiospores (13.4 × 4.5 µm, Marr & Stuntz 1973) Specimens collected in northwest China exhibit slightly smaller basidiomata and basidiospores sizes compared to the described type specimens from Italy.

84. *Ramaria persicinoflava* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 19 (2024)

Original description in Li et al. (2024).

85. *Ramaria pseudoobtusissima* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 o–p and Fig. 108

Mycobank: MB 853364

Etymology: “*pseudoobtusissima*” signifies that the species is similar to *R. obtusissima*.

Diagnosis: Basidiomata are dull yellow to salmon-colored; apices are broadly rounded, crowded, and concolorous with branches; hyphal and basidia lack clamps.

Type: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3564 (Holotype, MHHNU 10064, GenBank Acc. No.: ITS = PP467151, nrLSU = PP493476, *tef1-α* = PP480364).

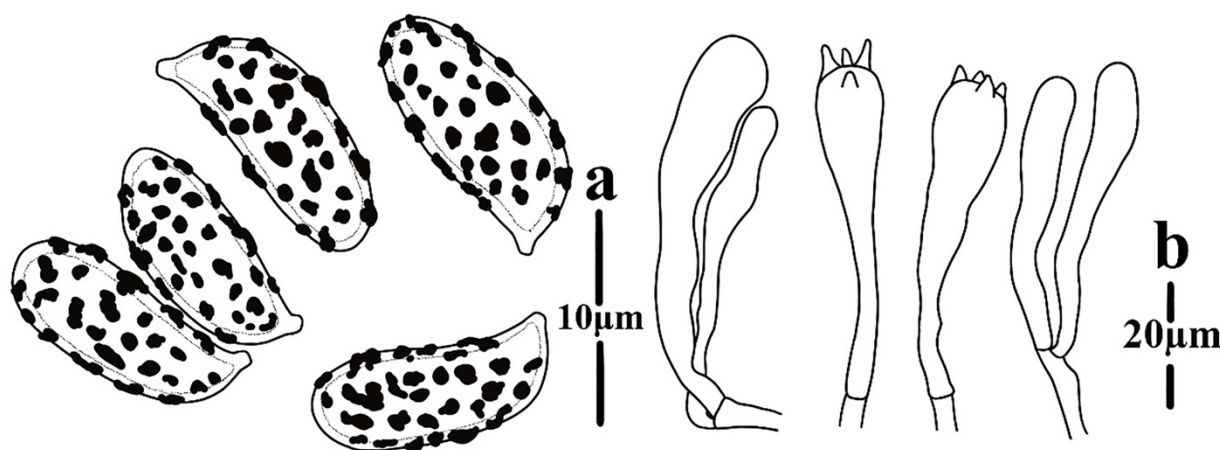


Fig. 108 Microscopic features of *R. pseudoobtusissima* (MHHNU 10064). a basidiospores; b basidia. Scale bars: a = 10 µm, d = 20 µm.

Description: *Basidiomata* 8–11 × 6–7 cm, solitary to gregarious. *Stipes* 2–3 × 3–4 cm, single to falsely fasciculate; off-white (1A1) at base, surface pale yellow (2A3) to salmon (6A4); surface smooth; with abortive branches; changing color to weakly grayish orange (6B5) where handled; context of stipe off-white (1A1) to pale yellow (2A3) when fresh, paler than hymenium, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* several, ascending, nearly terete. *Branches* in 3–5 ranks, major branches and upper branches commonly polychotomous; branches dull yellow (3B3) to melon yellow (5A6); axils broadly rounded, mostly U-shaped; internodes all short; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, pastel yellow (2A4) to pale orange (5A3). *Apices* broadly rounded, crowded, short digitate at maturity, polychotomous, concolorous. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2] (9.7–)10.4–13.6(–13.8) × (3.6–)3.9–

5.9(–6.5) µm, $L_m = 12.00$ µm, $l_m = 4.77$ µm, $Q = (1.97–)2.14–2.86(–2.91)$, $Q_m = 2.47 \pm 0.23$, subcylindrical to long-ellipsoid; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. *Basidia* 52–70 × 6–12 µm, clavate, without basal clamps; sterigmata 4, 3–5 µm long, stout and straight, somewhat scattered. *Hymenium* unthickening, 60–75 µm. *Subhymenium* extensive, hyphae, interwoven, 2–5 µm diam, thin-walled, without clamps. *Contextual hyphae:* *Tramal hyphae* of stipe 5–18 µm wide, loosely parallel, ampulliform inflations up to 20 µm broad, with coarse ornamentation; *tramal hyphae* of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 20 µm broad; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved forests or mixed forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Sichuan, Xizang).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Muge Lake, in the *Abies* and *Rhododendron* Forest, altitude 3600 m, 3 September 2021, P. Zhang 4231 (MHHNU 10731); same city, Waze Township, in *Picea* forest, altitude 3800 m, 1 September 2018, P. Zhang 3571 (MHHNU 10071).

Commentary: Many *Ramaria* species have broadly rounded apices. However, in *R. pseudoobtusissima*, the branches near the apices are also quite rounded, and some basidiomata exhibit a swelling morphology at the apices that is wider than the nearby branches. *Ramaria pseudoobtusissima* shares a similar salmon-orange to yellowish basidiomata orange color and broadly rounded apices with *R. obtusissima*, but the latter possesses clamps, and smaller basidiospores (10–13 × 3–3.5 µm, Corner 1950). While *R. pseudoobtusissima* resembles *R. largentii* from the United States, the basidiospores of the latter are significantly

larger (13.4 × 4.5 µm, Marr & Stuntz 1973).

86. *Ramaria robustibrunnea* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 q–r and Fig. 109

Mycobank: MB 853366

Etymology: *robustibrunnea* = *robust* + *brunnea*, indicating that the species has a stout stipe and changes color to brown when handle.

Diagnosis: Basidiomata are medium to large size, dark yellow to salmon; stipe is stout, fleshy to fibrous; apices are yellow when young, becoming brownish, or concolorous with branches at maturity; basidia base and hyphae lack clamps; basidiospores are roughened in profile.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, 26 August 2017, P. Zhang 2769 (Holotype, MHHNU 9269, GenBank Acc. No.: ITS = PP467169, nrLSU = PP493492, *tef1-α* = PP480377).

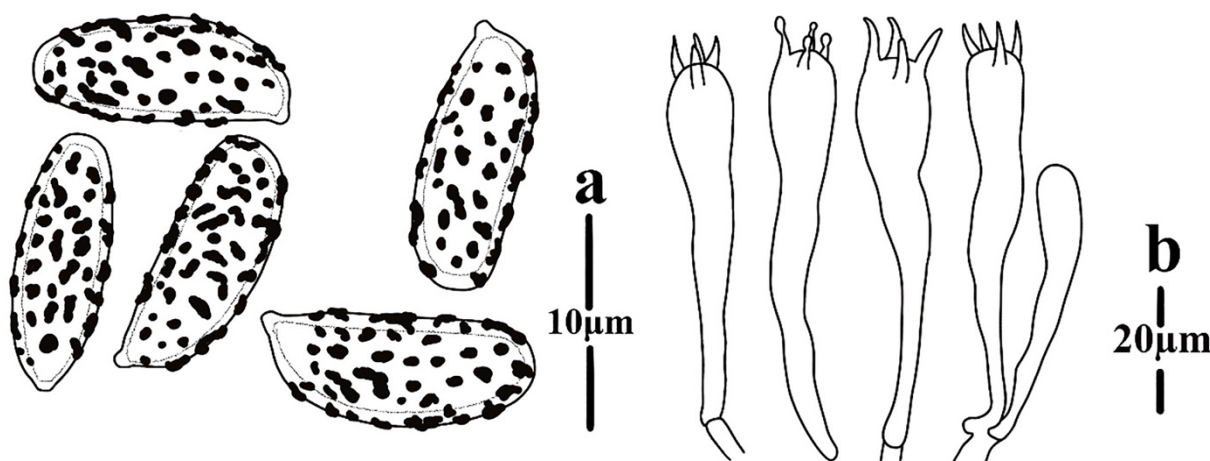


Fig. 109 Microscopic features of *R. robustibrunnea* (MHHNU 9269). a basidiospores; b basidia. Scale bars: a = 10 µm, d = 20 µm.

Description: Basidiomata 12 × 10 cm, medium sized to large. Stipes up to 5 × 5 cm, single, slender; off-white (1A1) below substrate level, surface pale yellow (2A3) to cream (4A3) upward; surface smooth; with abortive branches; changing color to weakly brownish orange (6C3) where handled; context of stipe off-white (1A1) when fresh, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. Major branches several, stout, ascending, terete. Branches in 3–5 ranks, slender, major branches commonly polychotomous and upper branches mostly dichotomous; branches salmon (6A4) to melon yellow (5A6); axils mixed narrowly rounded and broadly rounded, mixed U-shaped and U-shaped; internodes diminishing gradually at maturity, lower internodes long; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, off-white (1A1) to pale yellow (2A3). Apices slender and acute, crowded, polychotomous, pastel yellow (2A4) when young, turned to brown (6E8) by maturity, or concolorous with branches. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2] (9.6–)9.9–12.6(–12.9) × (3.3–)3.7–5.5(–5.7) µm, $L_m = 11.01$ µm, $l_m = 4.69$ µm, $Q = (1.90–)2.03–2.90(–3.17)$, $Q_m = 2.38 \pm 0.27$, subcylindrical to long-ellipsoid; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly

cyanophilous warts; hilar not conspicuous. Basidia 50–70 × 8–12 µm, clavate, without basal clamps; sterigmata 4, 5–8 µm long, stout, long and straight, somewhat scattered. Hymenium unthickening, 60–80 µm. Subhymenium extensive, hyphae, interwoven, 2–5 µm diam, thin-walled, without clamps. Contextual hyphae: Tramal hyphae of stipe 5–18 µm wide, loosely parallel, ampulliform inflations up to 20 µm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 20 µm broad; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved and coniferous mixed forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4362 (MHHNU 10862), P. Zhang 4368 (MHHNU 10868), P. Zhang 4370 (MHHNU 10870), P. Zhang 4373 (MHHNU 10873); same city, Sewulong Village, within a *Picea* forest, altitude 3450 m, 5 September 2018, P. Zhang 3602 (MHHNU 10102); same location, in a forest with *Quercus*, altitude 3600 m, 21 August 2017, P.

Zhang 2591 (MHHNU 9091), P. Zhang 2593 (MHHNU 9093), P. Zhang 2594 (MHHNU 9094), P. Zhang 2595 (MHHNU 9095); same location, in mixed forests dominated by *Picea asperata* and *Betula platyphylla*, altitude 3700 m, 27 August 2017, P. Zhang 2779 (MHHNU 9279), P. Zhang 2780 (MHHNU 9280).

Commentary: The robust stipe of *R. robustibrunnea* is a key characteristic for distinguishing this species. Among *Ramaria*, several salmon-colored species have robust stipes, such as *R. laeviformosoides* and *R. laeviflava*, but these two species have nearly smooth basidiospores, unlike the rough basidiospores of *R. robustibrunnea*. Other species with robust stipes, such as *R. sinolargentii* (ser. *Neoformosae*) and *R. robustiflava* (ser. *Laetae*), exhibit clamps, which are absent in *R. robustibrunnea*. *Ramaria compressipes* (ser. *Flavescentoides*) has a thicker stipe, but its internodes and branches are shorter, forming a cauliflower-like appearance, unlike the basidiomata form in *R. robustibrunnea*. Additionally, *R. gelatinostipes* (ser. *Gelatinosae*) has a robust stipe, but its

stipe is gelatinous, distinguishing it from the fleshy to fibrous stipe of *R. robustibrunnea*.

87. *Ramaria sinolargentii* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 s–t and Fig. 110

Mycobank: MB 853356

Etymology: “*sinolargentii*” = *sino* + *largentii*, indicating that the species has large basidiospores and is somewhat similar to the American species *Ramaria largentii*.

Diagnosis: Basidiomata are medium sized to large, salmon to orange; stipe is fleshy to fibrous, concolorous with branches; generally not changing color, but apices turn brownish gray when bruised; presence of clamps; grow in *Picea* and *Abies* forests.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Jiangda County, in *Picea* and *Abies* forest, altitude 3850 m, 13 August 2023, Zuo H. Chen 34000 (Holotype, MHHNU 34000, GenBank Acc. No.: ITS = PP467158).

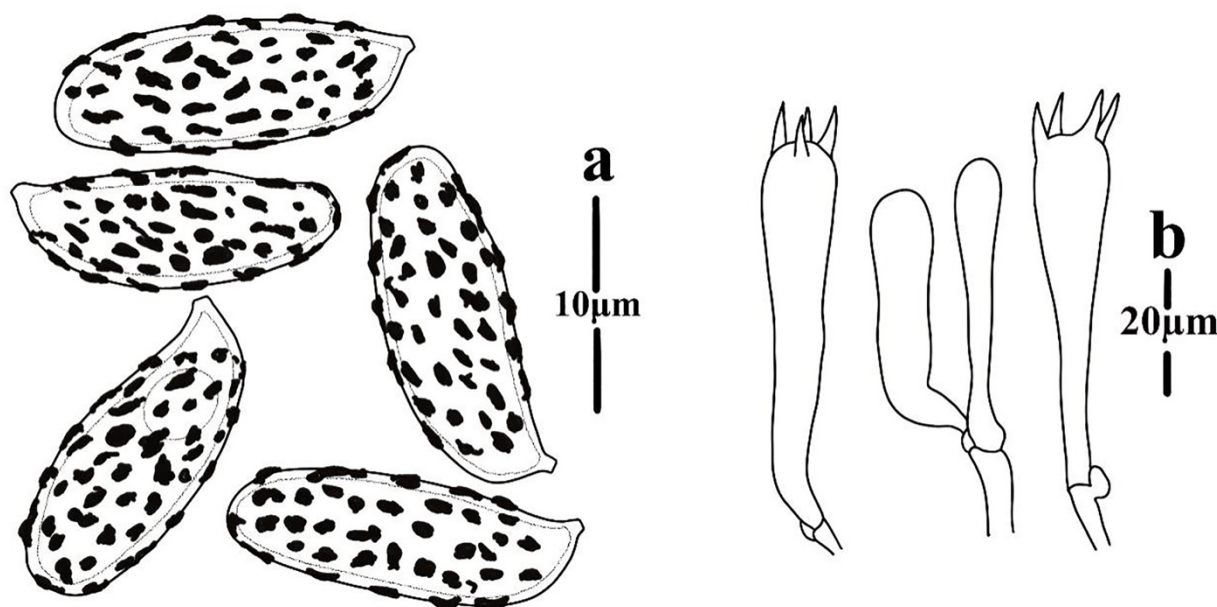


Fig. 110 Microscopic features of *R. sinolargentii* (MHHNU 34000). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Description: *Basidiomata* 5–12.5 × 5–8.5 cm, solitary to gregarious. *Stipes* up to 2–5 × 3–5 cm, to compound-connate, rounded base; off-white (1A1) below substrate level, surface pale yellow (2A3) to salmon (6A4) upward; surface smooth; without abortive branches; not changing color to weakly watery brunnescent where handled; context of stipe off-white (1A1) when fresh, paler than hymenium, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* several, ascending, hardly terete. *Branches* in 3–5 ranks, major branches commonly polychotomous and upper branches mostly dichotomous; branches salmon (6A4) to carrot red (6B7); axils narrowly rounded when young, broadly rounded and mostly U-shaped at maturity; internodes short when young, diminishing gradually at maturity, terete, subparallel upward; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, off-white (1A1) to pale orange (5A5). *Apices* molar-like when young, digitate at maturity, dichotomous, 2–10 mm, concolorous with branches or slightly changing color to

brownish gray (6E2). Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [80/3/3] (13.3–)13.7–17.4(–18.5) × (4.1–)4.4–6.1(–6.5) μm, $L_m = 15.36$ μm, $l_m = 5.30$ μm, $Q = (2.42–)2.50–3.32(–3.70)$, $Q_m = 2.92 \pm 0.26$, subcylindrical; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 55–80 × 8–13 μm, long, clavate, with basal clamps; sterigmata 4, 4–7 μm long, stout and straight, somewhat scattered. *Hymenium* unthickening, 70–85 μm. *Subhymenium* extensive, hyphae, interwoven, 2–5 μm diam, thin-walled, with clamps. *Contextual hyphae*: Tramal hyphae of stipe 3–12 μm wide, loosely parallel, ampulliform inflations up to 15 μm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 15 μm broad; clamps conspicuously; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in *Picea* and *Abies*

forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Dege County, Manigange Township, Que'er Mountain, in *Picea* and *Abies* forest, altitude of 4100 m, 14 August 2023, Zuo H. Chen 34029 (MHHNU 34029); same city, Jiangda County, in *Picea* and *Abies* forest, 30 July 2004, Zai W. Ge 227 (HKAS 46007); same city, Dege County, Langduo Township, Lunmai Village, in *Picea* and *Abies* forest, altitude 3650 m, 9 August 2023, Zuo H. Chen 33941 (MHHNU 33941), Zuo H. Chen 33944 (MHHNU 33944); same city, Seda County, in *Picea* and *Abies* forest, altitude 3650 m, 8 August 2023, Zuo H. Chen 33922 (MHHNU 33922); Kangding City, Gongga Township, new Gongga Monastery, within a *Picea* forest, altitude 3900 m, 4 September 2018, Ping Zhang 3596 (MHHNU 10096).

Commentary: *Ramaria sinolargentii* is a large spored species in *Ramaria*. It shares very similar characteristics with the *R. distinctissima* in the southwestern China, *R. luteoaurantiaca* and *R. flavicingula* in Europe, and *R. largentii*

in American. These features include the orange-yellow coloration of the basidiomata, the presence of clamps at the base of the basidia, and their growth in *Picea* and *Abies* forests (Marr & Stuntz 1973; Petersen 1988, 1989; Franchi & Marchetti 2021). The distinguishing feature of *R. sinolargentii* is that it has the largest basidiospores among these species and exhibits an orange-red coloration.

88. *Ramaria sinosubtilis* P. Zhang & J. Zhong, **sp. nov.** Fig. 28 u–v and Fig. 111

Mycobank: MB 853363

Etymology: “*sinosubtilis*” means the species is similar to *R. subtilis* and was collected in China.

Diagnosis: Basidiomata are gold yellow to orange; lack clamps; branches are slender; stipe fleshy to fibrous.

Type: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3560 (Holotype, MHHNU 10060, GenBank Acc. No.: ITS = PP467164, nrLSU = PP493487, *tef1-α* = PP480373).

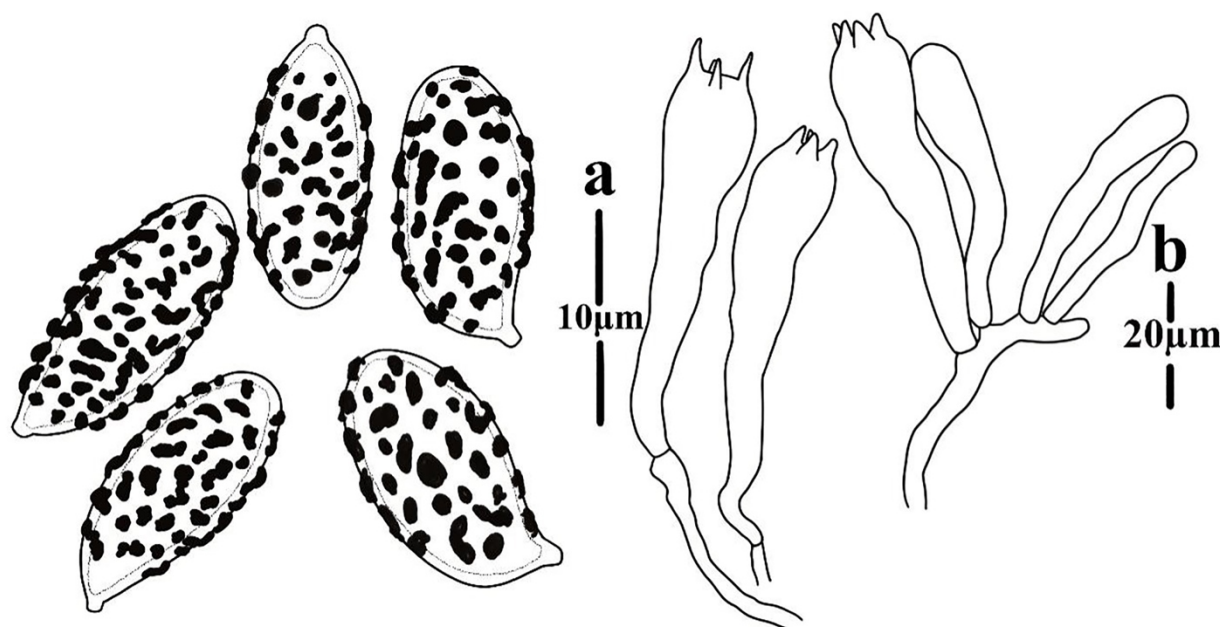


Fig. 111 Microscopic features of *R. sinosubtilis* (MHHNU 10060). a basidiospores; b basidia. Scale bars: a = 10 μ m, b = 20 μ m.

Description: *Basidiomata* 8 × 6 cm, obtriangular in outline. *Stipes* up to 2 × 2 cm, single to falsely fasciculate, tapering gradually downward; off-white (1A1) below substrate level, surface dull yellow (3B3) to cream (4A3) upward; surface smooth; with abortive branches; changing color to weakly lemon yellow (3B8) to brownish orange (6C3) where handled; context of stipe off-white (1A1) when fresh, paler than hymenium, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. *Major branches* several, ascending, hardly terete. *Branches* in 3–5 ranks, slender, major branches commonly polychotomous and upper branches mostly dichotomous; branches salmon (6A4) to melon yellow (5A6); axils mixed narrowly rounded and broadly rounded, mixed U-shaped and U-shaped; internodes diminishing gradually at maturity, lower internodes long; context of main branches and upper branches fleshy to fibrous, not gelatinous or slippery, off-white (1A1) to pale orange (5A5). *Apices* are

slender and acute, crowded, polychotomous, pale orange (5A3) to vivid yellow (2A8), or concolorous with branches. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2] (11.1–)11.5–14.9(–15.7) × (3.9–)4.1–6.4(–6.9) μ m, L_m = 12.85 μ m, l_m = 5.37 μ m, Q = (1.90–)1.94–3.14(–3.46), Q_m = 2.45 ± 0.38, subcylindrical to long-ellipsoid; conspicuously roughened in profile; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar not conspicuous. *Basidia* 55–70 × 10–15 μ m, clavate, without basal clamps; sterigmata 4, 2–5 μ m long, stout, short and straight, somewhat scattered. *Hymenium* unthickening, 60–75 μ m. *Subhymenium* extensive, hyphae, interwoven, 2–5 μ m diam, thin-walled, without clamps. *Contextual hyphae:* Tramal hyphae of stipe 5–18 μ m wide, loosely parallel, ampulliform inflations up to 20 μ m broad, with coarse ornamentation; tramal hyphae of branches

central hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 20 µm broad; without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in *Quercus* forests or broad-leaved and coniferous mixed forests. Basidiomata occurs in summer and autumn.

Distribution: In southwest China (Yunnan, Xizang).

Additional materials examined: CHINA, YUNNAN PROVINCE: Deqin County, Feilaisi Forest Park, altitude 3400 m, 19 August 2018, P. Zhang 3471 (MHHNU 9971). CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila National Forest Park, in a mixed forest dominated by *Picea* and *Quercus*, altitude 3200 m, 25 August 2018, P. Zhang 3493 (MHHNU 9993), 3494 (MHHNU 9994), 3495 (MHHNU 9995).

Commentary: *Ramaria sinosubtilis* bears a striking resemblance to *R. aureolinearis*, which was collected from Jilin Province in northern China. The basidiospores sizes are quite similar, with the difference being that the stipes of the former are slightly stouter, and its apices are yellow, while the basidiospores sizes are slightly larger (11.68 × 4.13 µm, as measured in this study). Similarly, *R. sinosubtilis* is also similar to *R. aurea*, *R. subtilis*, and *R. albidoflava*. For more details, refer to the discussion section on *R. aureolinearis*.

89. *Ramaria subcolumnaris* L. Fan, Ying Li & N. Mao, in Li, Mao, Zhang, Fu & Fan, Mycology: 10.1080/21501203.2024.2388910, 19 (2024)

Original description in Li et al. (2024).

Ramaria ser. Pallidochraceus P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852766

Etymology: “*pallidus*” means “pale” in Latin, while “*ochraceus*” derives from “ochre”, “*pallidochraceus*” refers to the basidiomata color being pale ochre.

Type species: *R. pallidochraceus* P. Zhang & J. Zhong.

Diagnosis: Basidiomata pallid ochre in color; bruising changes color to brownish; branches subparallel.

Commentary: This series has been collected in China and comprises one species, another species is *R. synaptopoda* Marr & D.E. Stuntz.

90. *Ramaria pallidochracea* P. Zhang & J. Zhong, **sp. nov.** Fig. 29 a–b and Fig. 112

Mycobank: MB 853198

Etymology: *pallidochracea* = *pallida* + *ochracea*, referring to the basidiomata being pale yellowish brown in color.

Diagnosis: Basidiomata are medium sized, ranging from bright yellow to pallid brown in color; basidiospores are short and broadly shaped; bruised areas turn brownish; hyphae and basidia exhibit conspicuous clamps, with basidia being short and stout.

Type: CHINA, HUBEI PROVINCE: Yichang City, Shennongjia National Nature Reserve, in mixed forests dominated by *Quercus*, altitude 1600 m, 4 September 2002, P. Zhang 253 (Holotype, MHHNU 6753, GenBank Acc. No.: ITS = PP467246, nrLSU = PP493554, *tef1-α* = PP480420).

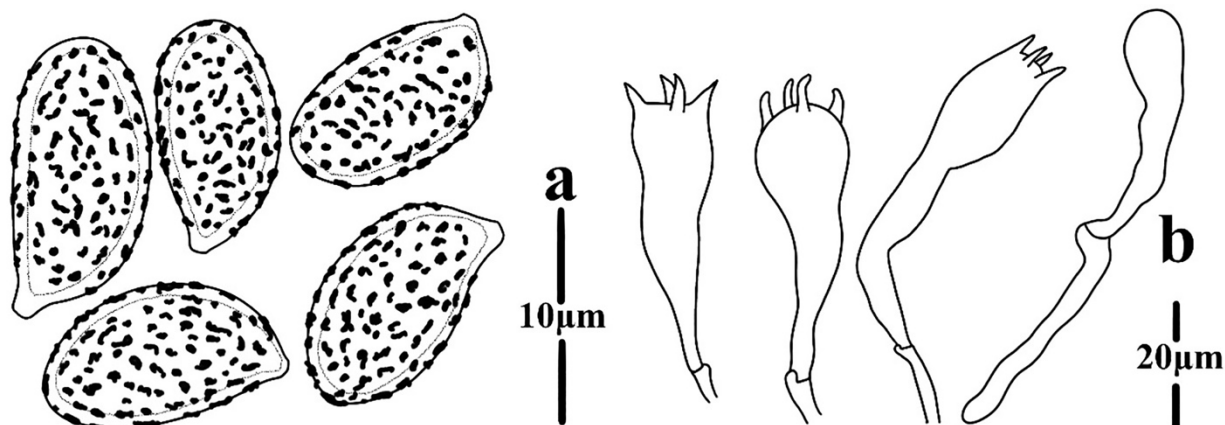


Fig. 112 Microscopic features of *R. pallidochracea* (MHHNU 6753). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: Basidiomata 11 cm high and 7 cm broad. Stipe 0.8 × 3–4 cm, fasciculate or with a very small point of union at the base, or solitary, fleshy, tapering gradually downward, tomentose at base, without abortive branchlets, brunnescent where handled; off-white (1A1) downward, pale yellow (2A3) above; flesh off-white (1A1), fleshly, not gelatinous or slippery. Major branches several, small to large, fleshy, solid, ascending, smooth, concolorous with branches above, concolorous with stipe downward; flesh off-white (1A1), turn to yellow ochre (5C7) when hurt. Branches in 2–4 ranks, ascending, terete, off-white (1A1) when young, pale yellow (2A3) to salmon (6A4) at age, dichotomous; flesh more pallid, brittle to brittle-fibrous, gelatinous; internodes diminishing gradually at maturity; axils narrowly rounded throughout, V-shaped. Apices are long, acute and slender, double-dichotomous, pastel yellow (2A4). Odor and taste faintly fabaceous.

Basidiospores [40/2/2] 10.0–12.0(–13.0) × 4.0–4.8 µm, $L_m = 10.92$ µm, $l_m = 4.41$ µm, $Q = (2.08)–2.22–2.86(–3.00)$, $Q_m = 2.49 \pm 0.20$, ellipsoid, slightly roughened in profile; hilar prominent; ornamentation of small, randomly scattered flat warts. **Basidia** 42–52 × 8–15 µm, clavate, without clamps; sterigmata 4, long, stout, curved. **Subhymenium** extensive, hyphae. **Hymenium** thickening. **Tramal hyphae of stipe** 4–14 µm wide, hyaline, conspicuously clamped, loosely parallel, not agglutinated or adherent; ampulliform clamps up to 17 µm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** up to 5–15 µm wide, hyaline, thin walled, conspicuously clamped, loosely parallel, more inflated inward, agglutinated to adherent, loosely parallel; ampulliform clamps up to 18 µm broad, gloeoplerous hyphae occasionally.

Ecology: Found in broad-leaved forests. Basidiomata

occurs in summer and autumn.

Distribution: Known from central China (Hubei).

Additional materials examined: CHINA, HUBEI PROVINCE: Yichang City, Shennongjia National Nature Reserve, in a broad-leaved forest, altitude 2000 m, 3 September 2002, P. Zhang 244 (MHHNU 6744), P. Zhang 248 (MHHNU 6748); same location, in mixed forests dominated by *Quercus*, altitude 1600 m, 4 September 2002, P. Zhang 250 (MHHNU 6750), P. Zhang 252 (MHHNU 6752).

Commentary: *Ramaria cystidiophora* Corner and its five

variants exhibit morphological similarities to *R. pallidochracea*. The short and broad basidiospores ($L_m = 11.04 \times 5.87 \mu\text{m}$) distinguish *R. pallidochracea* from *R. cystidiophora* and its five variants. Furthermore, *R. synaptopoda* is closely related to *R. pallidochracea* in the two-gene phylogenetic analysis. This species is characterized by entirely yellow basidiomata with small red patches on the lower stipe, 3-rank branches, but it lacks clamps. All these variants feature clamps, with similar-sized basidiospores and basidiomata coloration as follows.

Table 2 Basidiospore size and basidiomata color of *R. cystidiophora* and its five variants

Species	Literature	Average basidiospores size	Basidiomata color
<i>R. cystidiophora</i>	Corner 1950	5.5–6.5 × 2.5–3.5 μm	Buff yellow to warm buff
<i>R. cystidiophora</i> var. <i>cystidiophora</i>	Corner 1950	8 × 3.6 μm	Buff yellow to warm buff
<i>R. cystidiophora</i> var. <i>citronella</i>	Marr & Stuntz 1973	10.3 × 4.2 μm	Caramel brown
<i>R. cystidiophora</i> var. <i>fabiolens</i>	Marr & Stuntz 1973	9.7 × 4.2 μm	Light yellow
<i>R. cystidiophora</i> var. <i>maculans</i>	Marr & Stuntz 1973	11.8 × 4.0 μm	Light yellow
<i>R. cystidiophora</i> var. <i>anisata</i>	Petersen 1988a	8.2 × 3.66 μm	Pallid salmon

In fact, Kauffman described cystidia only in *R. cystidiophora*, Coker didn't find cystidia in the North American species which he studied, nor have they been reported by European mycologists (Corner 1950; Marr & Stuntz 1973). Corner didn't find cystidia in the twenty species he examined. Corner doubted the accuracy of Kauffman's observation, suggesting it did not refer to excrescent hyphae or basidia in thickening hymenium in exceptionally humid surroundings.

Marr & Petersen found acanthodendroid gleoplerous structures in *R. cystidiophora* and its variants. Petersen first identified these structures in *R. cystidiophora* var. *citronella*. Since then, Marr has found this hyphal type in var. *cystidiophora*, var. *fabiolens*, var. *maculans*, and in *Clavaria aurea* var. *australis* Coker, which differs from *R. cystidiophora* by its clampless hyphae.

Ramaria* ser. *Pallidolilacinae P. Zhang & J. Zhong, **ser. nov.**
Mycobank: MB 852716

Etymology: Referring to the color of the branches, which is pale purple.

Type species: *R. pallidolilacina* P. Zhang & Z.W. Ge, in Zhang, Yang & Ge, Mycotaxon 94: 238 (2006)

Diagnosis: Branches and apices pallid lilac; stipe relatively small and tapering; basidia without clamps and basidiospores coarsely ornamented.

Commentary: This series comprises only one species collected in China. Additionally, other species in this group include *R. pallida* (Schaeff.) Ricken (= *R. mairei* Donk) from Europe and *R. acriscescens* Marr & D.E. Stuntz (= *R. fumosiavellanea* Marr & D.E. Stuntz) from North America. Among these three species, the basidiospores of *R. acriscescens* are relatively narrower ($10.1 \times 4.9 \mu\text{m}$), whereas *R. pallida* have basidiospores averaging $10.3 \times 5.4 \mu\text{m}$, which are shorter than those of *R. pallidolilacina* collected in China.

91. ***Ramaria pallidolilacina*** P. Zhang & Z.W. Ge, in Zhang, Yang & Ge, Mycotaxon 94: 238 (2006) Fig. 30 a–b and Fig. 113

Diagnosis: Branches and apices pallid lilac, relatively small; stipe white, tapering; basidiospores coarsely ornamented, without clamps.

Description: *Basidiomata* 13 cm high, up to 10 cm broad, repeatedly branched, usually obovate to subcircular in profile. *Stipe* 3 × 2 cm, single, tapering gradually downward, tomentose at base, smooth upward, without abortive branches, off-white to cream, not changing color on bruising; flesh off-white, solid, not gelatinous or slippery. *Major branches* 4–6, stout, up to 1 cm thick, ascending, concolorous to branches above. *Branches* 4–5 ranks, ascending, rugulose, polychotomous, pallid lilac, slowly becoming grayish purple with basidiospores deposit; internodes diminishing gradually upwards; axils rounded. *Apices* obtuse, rather crowded, 0.5–1 mm long, molar-like when young, broom-form or short-digitate by maturity, concolorous with the branches. Taste and odor not recorded.

Basidiospores [60/2/2] (10.0–) 10.5–13.0 (–14.0) × (4.5–) 5.0–6.0 (–7.0) μm , $Q = (1.62–) 1.85–2.40 (–2.60)$, $Q_m = 2.14 \pm 0.20$, ellipsoid, flattened adaxially, roughened in profile; wall up to 0.5 μm thick, cyanophilous; hilar appendix prominent; ornamentation of prominent, discrete, low warts and short ridges randomly placed. *Basidia* 60–85 × 9–11 μm , clavate, without clamps, cyanophilous, 4-spored; sterigmata 6–8 μm long. *Subhymenium* rudimentary, hyphal. *Hymenium* unthickening. *Tramal hyphae* of stipe 3–15 μm wide, hyaline, thin-walled, without clamps, interwoven; ampulliform septa and gloeoplerous hyphae not observed. *Tramal hyphae* of upper branches 3–10 μm wide, hyaline, thin-walled, loosely parallel, without clamps; gloeoplerous hyphae not observed.

Ecology: Solitary on soil in *Picea* forests. Basidiomata occurs in summer and autumn.

Distribution: known from southwestern China, northwest China, north China (Yunnan, Sichuan, Xizang, Xinjiang).

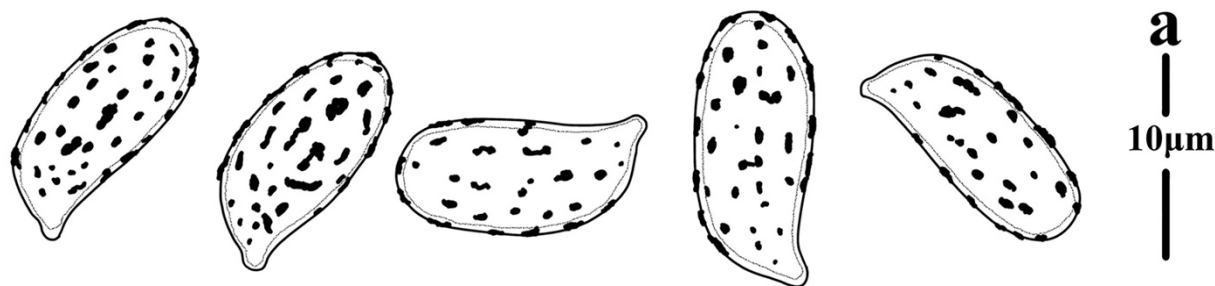


Fig. 113 Basidiospore features of *R. pallidolilacina*. Scale bar: a = 10 µm (Zhang et al. 2005).

Additional materials examined: CHINA, YUNNAN PROVINCE: Qujing City, Qilin District, near Longyuan Zhumushan Wind Farm, altitude 2250 m, 19 August 2022, P. Zhang 4717 (MHHNU 11217); Deqin County, Feilaisi Forest Park, altitude 3400 m, 19 August 2018, P. Zhang 3472 (MHHNU 9972); same county, Baima Snow Mountain Nature Reserve, altitude 3750 m, 18 August 2018, P. Zhang 3470 (MHHNU 9970); same location, 17 August 2018, P. Zhang 3446 (MHHNU 9946). SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, September 7, 2021, Zhang Ping 4375 (MHHNU 10875); same city, Mugecuo, in the *Abies* and *Rhododendron* forest, altitude 3600 m, 3 September 2021, Zhang Ping 4233 (MHHNU 10733); same location, in a *Abies* forest, altitude 3500 m, 21 August 2017, P. Zhang 2707 (MHHNU 9207); same city, Gongga Township, new Gongga Monastery, within a *Picea* forest, altitude 3900 m, 4 September 2018, P. Zhang 3605 (MHHNU 10105); same city, Gongga Mountain, in *Picea* forest, altitude 3500 m, 2 September 2018, P. Zhang 3584 (MHHNU 10084); same location, in broad-leaved forest with Fagaceae, altitude 3500 m, 1 August 2012, Ping Zhang 1208 (MHHNU 7708); same city, Waze Township, in *Picea* forest, altitude 3800 m, 1 September 2018, P. Zhang 3570 (MHHNU 10070), P. Zhang 3573 (MHHNU 10073), P. Zhang 3580 (MHHNU 10080); same location, in a mixed forest of *Abies* and *Picea*, altitude of 4000 m, 23 August 2017, P. Zhang 2737 (MHHNU 9237) and P. Zhang 2738 (MHHNU 9238); same city, Gongga Township, Sewurong II Village, altitude 3700 m, 26 August 2017, P. Zhang 2767 (MHHNU 9267), P. Zhang 2770 (MHHNU 9270), P. Zhang 2775 (MHHNU 9275); same location, in a forest with *Quercus*, altitude 3700 m, 21 August 2017, P. Zhang 2592 (MHHNU 9092). XIZANG AUTONOMOUS REGION: Changdu City, Leiwuqi, in a subalpine forest, 11 August 2004, Zai W. Ge 332 (HKAS 46112); Jiangda County, near Tongpu village, altitude 3300m, 2 August 2004, Zai W. Ge 260 (HKAS 46040); Linzhi, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 4000 m, 27 August 2018, P. Zhang 3541 (MHHNU 10041), P. Zhang 3563 (MHHNU 10063); XINJIANG UYGUR AUTONOMOUS REGION: Ili, Tekes County, Qiongkushitai, in a *Picea* forest, altitude 2000, 21 August 2019, Ping Zhang 3734 (MHHNU 10234). NEI MONGOL AUTONOMOUS REGION: Hulunbuir City, Genhe County, Delpur, altitude 1050 m, 8 August 2013, P. Zhang 1296 (MHHNU 7796), P. Zhang 1297 (MHHNU 7797).

Commentary: A group of taxa within *Ramaria* exhibiting lilac, violet, or purple coloration has been described previously (Petersen 1987). Several species are included in this group, such as *Gom. asiaticus* (R. H. Petersen & M. Zang) R. H. Petersen, *R. cedretorum* (Maire) Malencon, *R. fennica*

(P. Karst.) Ricken, *R. himalayensis* R. H. Petersen, *R. purpurissima* R. H. Petersen & Scates, *R. versatilis* Quél., can be distinguished from *R. pallidolilacina* by their production of clamped basidia.

Although *R. pallisa* (Schaeff.) Ricken (= *R. mairei* Donk) is a clampless species with purplish basidiomata, its purple tints appear only at the apices and its stipe is more prominent than that of *R. pallidolilacina* (Petersen 1974a). *Ramaria spinulosa* (Pers.:Fr.) Quél., reported from Europe and North America, also has purple tinged basidiomata and clampless basidia, resembling *R. pallidolilacina*. However, it differs by its distinctive cinnamon tan stipe surface and pale beige stipe flesh (Petersen 1985; Schild 1990).

Ramaria subspinulosa (Coker) Corner, characterized by smaller basidiospores and a lavender tinge of appearing only on the upper part of basidiomata when young (Corner 1950; Petersen 1987), is another similar species. *Ramaria acriscescens* (= *R. fumosiavellenea* Marr & Stuntz D. E), originally described from North America, display a violet color component and clampless basidia, but it is differentiated from *R. pallidolilacina* by its darker branches with grayish orange apices and less ornamented basidiospores (Marr & Stuntz 1973).

Ramaria* ser. *Pseudobotrytes (Franchi & M. Marchetti) P. Zhang & J. Zhong, **stat. nov.**

Lectotype: *R. stuntzii* Marr, Bibliotheca Mycol. 38: 118 (1974) [1973].

Diagnosis: 1) salmon to red-orange branches; 2) bright orange flesh; 3) stipe flesh strong amyloid; 4) basidiospores short and small.

Commentary: The series has only one species collected in China.

92. ***Ramaria rufoaurea*** P. Zhang & J. Zhong, **sp. nov.** Fig. 31 a–b and Fig. 114

Mycobank: MB 853196

Etymology: *rufoaureus* = “*rufus*” (red) + “*aurea*” (golden), referring to the basidiomata of the species being red-orange in color.

Diagnosis: Basidiomata medium sized to large, salmon to orange colored, with a slightly red coloration at maturity; stipe single to compound, stout, with a strongly amyloid stipe context; basidiospores less 10 µm in size, roughened in profile; hyphae and basidia base with clamps.

Type: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3526 (Holotype, MHHNU 10026, GenBank Acc. No.: ITS = PP467215, nrLSU = PP493529).

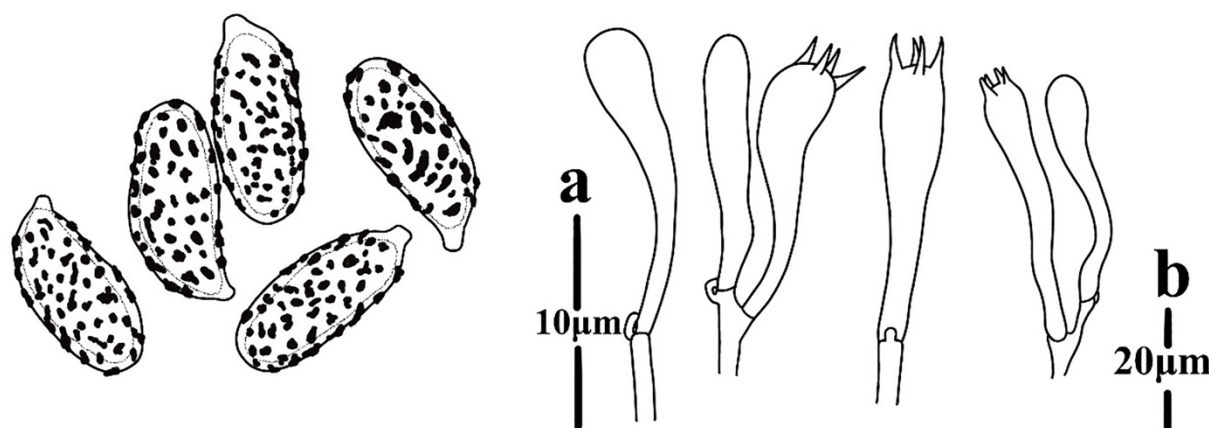


Fig. 114 Microscopic features of *R. rufoaurea* (MHHNU 10026). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 13 cm high and 8 cm broad, medium sized to large, usually single to fasciculate habit. *Stipe* 3 × 4 cm, single to compound, fleshy, large to robust, tapering gradually downward, rounded at base; off-white (1A1) at base, salmon (6A4) to cadmium orange (5A8) upward; not changing color or slightly changing color to grayish yellow (2B5) on bruising; surface longitudinally rugulose; occasionally with abortive branches; context of stipe off-white (1A1), fibrous, drying light in weight, easily penetrated. *Branches* in 3–6 ranks, major branches and branches above commonly polychotomous; young branches salmon (6A4) to orange (6A8) when young, pale orange (5A3) to salmon (6A4) at age, with slightly mandarin orange (6B8); axils narrowly rounded, mostly V-shaped; internodes diminishing gradually at maturity, lower internodes up to 4 cm; branches slender and crowded, commonly 2–5 mm, seldom over 1 cm diam, terete, ascending; context of main branches and upper branches gelatinous, orange (6A8). *Apices* rounded, short and crowded, 1–3 mm long, polychotomous, light orange (5A5) when young, mandarin orange (6B8) at maturity. Odor and taste faintly fabaceous.

Basidiospores [71/2/2] (7.5–)8.2–11.8(–11.1) × (3.2–)3.6–4.9(–5.2) µm, $L_m = 9.33$ µm, $l_m = 4.20$ µm, $Q = (1.71)–1.92–2.72(–3.03)$, $Q_m = 2.24 \pm 0.26$, subcylindrical; ornamented with conspicuously warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 45–65 × 7–13 µm, clavate, with basal clamps; sterigmata 4, 3–6 µm long, incurved or straight, slightly divergent. *Hymenium* unthickening, 50–70 µm. *Subhymenium* extensive, 15–30 µm thick, hyphae, interwoven, 3–6 µm diam, thin-walled, with clamps. *Contextual hyphae*: Tramal hyphae of stipe 3–15 µm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 19 µm, with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 18 µm, with smooth and thin wall; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae common, 7–10 µm diam.

Ecology: Found in forests with *Quercus semecarpifolia*. *Basidiomata* occurs in summer and autumn.

Distribution: Known from southwestern China (Xizang).

Additional materials examined: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*,

altitude 3400 m, 26 August 2018, P. Zhang 3507 (MHHNU 100207), P. Zhang 3509 (MHHNU 100209), P. Zhang 3526 (MHHNU 100226); same city, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3565 (MHHNU 10056).

Commentary: The distinguishing feature of this species is its yellow-orange basidiomata, which develops a slightly reddish-orange hue as they mature. It possesses a stout stipe with a strongly amyloid stipe context, and the upper branches context exhibits a reddish-orange coloration. Its closest relative, *R. stuntzii*, shares relatively small basidiospores but differs significantly in appearance. *Ramaria stuntzii* displays a bright red basidiomata color and lacks clamps, whereas *R. rufoaurea* presents salmon to orange hues with a hint of reddish-orange and distinct clamps (Marr & Stuntz 1973). Furthermore, *R. rufoaurea* has only been found in high-altitude mountain *Quercus* forests in Xizang to date.

Ramaria* ser. *Pseudocystidiophorae P. Zhang & J. Zhong, ser. nov.

Mycobank: MB 852756

Etymology: “*pseudos*” means “similar”, and “*cystidiophoras*” refers to *R. cystidiophora*.

Type species: *R. pseudocystidiophora* P. Zhang & J. Zhong.

Diagnosis: *Basidiomata* medium sized, yellow to pallid salmon in color; apices bright yellow or concolorous with branches; basidiospores short and narrow; bruising does not change color to brownish; hyphae and basidia conspicuously possess clamps.

Commentary: The series comprises only one species collected in China.

93. ***Ramaria pseudocystidiophora*** P. Zhang & J. Zhong, sp. nov. Fig. 32 a–b and Fig. 115

Mycobank: MB 853199

Etymology: “*pseudocystidiophora*” means this species resembles *R. cystidiophora*.

Diagnosis: *Basidiomata* medium sized, yellow to pallid brown in color; apices bright yellow or concolorous with branches; basidiospores short and narrowly shaped; bruising does not change color, though sometimes turns brownish; hyphae and basidia conspicuously possess clamps.

Type: CHINA, XIZANG AUTONOMOUS REGION: Linzhi,

Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3523 (Holotype, MHHNU 10023, GenBank Acc. No.: ITS = PP467249, nrLSU = PP493557, *tef1-α* = PP480423).

Description: *Basidiomata* 11 cm high and 9–15 cm broad. *Stipe* 1 × 1 cm, single to fasciculate or with a very small point of union at the base, fleshy, tapering gradually downward, tomentose at base, without abortive branchlets, not changing color on bruising, off-white (1A1) downward, pale yellow (2A3) above; flesh off-white (1A1), fleshy, not gelatinous or slippery. *Major branches* several, stout and crowded, fleshy, solid,

ascending, smooth, concolorous with branches above, concolorous with stipe downward; flesh off-white (1A1), not changing color on bruising. *Branches* in 2–4 ranks, ascending, terete, off-white (1A1) when young, pale yellow (2A3) to light orange (5A5) at age, dichotomous; flesh more pallid, brittle to brittle-fibrous, more or less gelatinous; internodes diminishing gradually at maturity; axils narrowly rounded throughout, V-shaped. *Apices* short, acute and slender, double-dichotomous, pale yellow (2A3). Odor and taste faintly fabaceous.

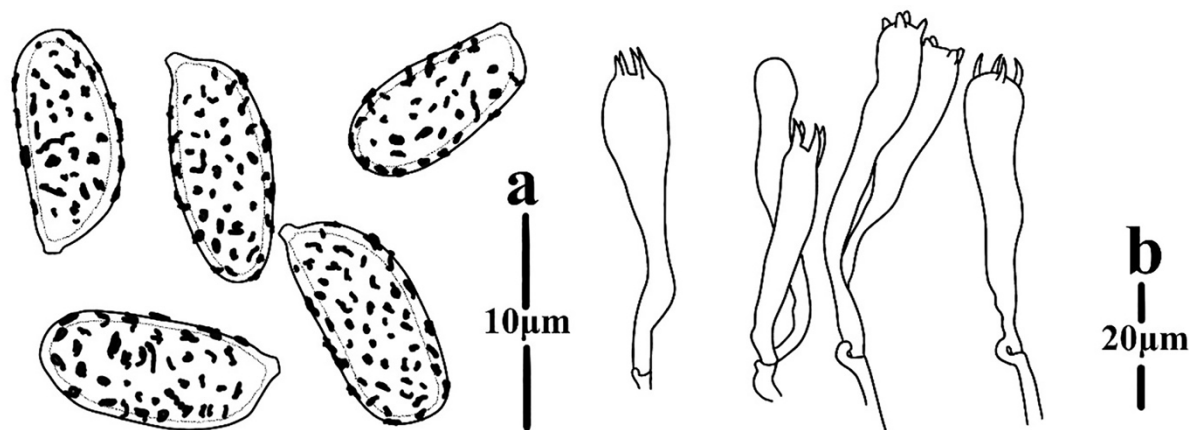


Fig. 115 Microscopic features of *R. pseudocystidiophora* (MHHNU 10023). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [60/2/2] (7.9–)8.2–11.3(–12.0) × (2.7–)2.9–4.2(–4.4) μm, $L_m = 9.27$ μm, $l_m = 3.46$ μm, $Q = (2.08–)2.22–2.86(–3.00)$, $Q_m = 2.71 \pm 0.28$, ellipsoid to cylindrical, slightly roughened in profile; hilar prominent; ornamentation of small, randomly scattered flat warts. **Basidia** 35–50 × 7–11 μm, clavate, without clamps; sterigmata 4, long, stout, curved. **Subhymenium** extensive, hyphae. **Hymenium** thickening. **Tramal hyphae of stipe** 6–12 μm wide, hyaline, conspicuously clamped, loosely parallel, not agglutinated or adherent; ampulliform clamps up to 14 μm broad, not unusually thick-walled, with delicate ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** up to 5–13 μm wide, hyaline, thin walled, conspicuously clamped, loosely parallel, more inflated inward, with some enlarged, sub-ellipsoid pseudo-cystidiophora hyphae, more or less agglutinated to adherent, loosely parallel; ampulliform clamps up to 14 μm broad, gloeoplerous hyphae occasionally.

Ecology: Found in the forests with *Quercus* or mixed forests with *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Sichuan, Xizang).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 4000 m, 7 September 2021, P. Zhang 4325 (MHHNU 10825), P. Zhang 4334 (MHHNU 10834), P. Zhang 4360 (MHHNU 10860). XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3545 (MHHNU 10045); same city, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3508 (MHHNU 10008), P. Zhang 3510 (MHHNU 10010).

Commentary: Species morphologically resembling *R.*

pseudocystidiophora include *R. pallidochracea*, *R. cystidiophora* and its variants. However, these species can be easily distinguished by basidiospores size: *R. pseudocystidiophora* ($L_m = 9.27 \times 3.46$ μm), *R. pallidochracea* with rounded basidiospores ($L_m = 11.04 \times 5.87$ μm), and the basidiospores of *R. cystidiophora* and its variants are not as narrow as those of *R. pseudocystidiophora*.

Ramaria* ser. *Robustipurpureae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852714

Etymology: *robustipurpurea* = “robust” (stout) and “purpurea” (pale purple color), indicating robust stipes and pale purple basidiomata.

Type species: *R. robustipurpurea* P. Zhang & J. Zhong

Diagnosis: Basidiomata pale purple in color; stipe off-white, single, stout, fleshy, does not change color when injured; branches persistently maintain their purple color, even when mature or dry; basidia base and hyphae with clamps.

Commentary: The series has only one species collected in China.

94. ***Ramaria robustipurpurea*** P. Zhang & J. Zhong, **sp. nov.** Fig. 33 a–b and Fig. 116

Mycobank: MB 853197

Etymology: *robustipurpurea* = “robust” (stout) and “purpurea” (purple color), indicating that this species has robust stipes and purple basidiomata.

Diagnosis: Basidiomata purple in color; stipe off-white, single, stout, fleshy, does not change color when injured; branches persistently maintain their purple color, even when mature or dry; basidia base and hyphae with clamps.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Nanhua

County, brought from mushroom market, 9 August 2016, P. Zhang 2377 (Holotype, MHHNU 8877, GenBank Acc. No.: ITS = PP467142, nrLSU = PP493469, *tef1-α* = PP480359).

Description: *Basidiomata* 17 cm high and 12 cm broad, nearly circular to very broadly obovate in outline. *Stipe* 9 × 6 cm, single, massive, tapering gradually downward, rounded below; off-white at base (1A1), violet-white (17A2) to lilac (15B4) above; weakly changing color to brownish orange (6C3); fine white tomentum increases, otherwise smooth; with abortive branches; context of stipe off-white (1A1) when fresh,

fleshy, solid, hard when dry. *Major branches* 3–4, thick, up to 3 cm thick, terete; *Branches* in 3–6 ranks, abruptly arising from major branches, terete, crowded when young, short at maturity; lilac (15B4) to reddish lilac (14B4); axils rounded, U shaped; internodes short throughout. Context of main branches and upper branches fleshy, solid, off-white (1A1). *Apices* cusped when young, dichotomous to double-dichotomous at maturity, minutely pointed, pale violet (17A3) to pale violet (17A3). Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

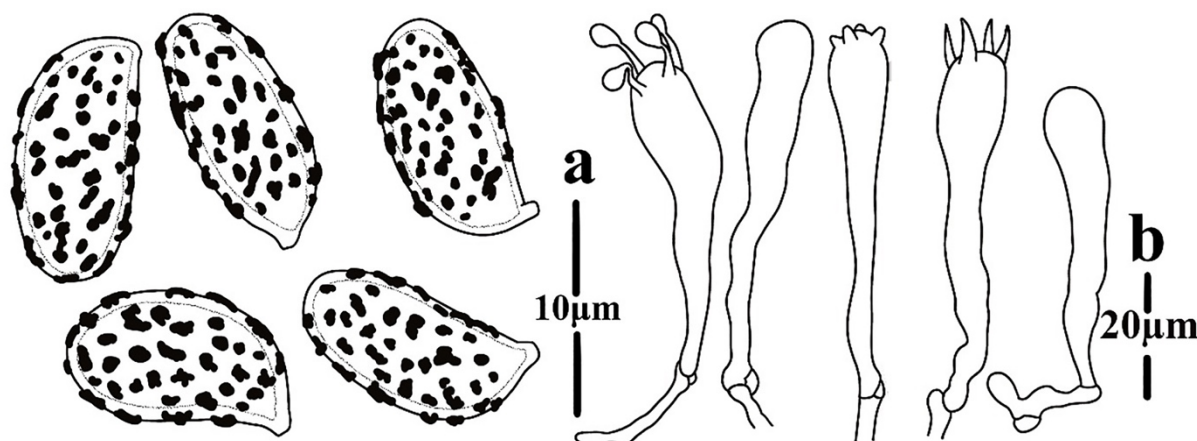


Fig. 116 Microscopic features of *R. robustipurpurea* (MHHNU 8877). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [60/2/2](9.9–)10.5–12.3(–12.3) × (4.8–)5.3–6.6(–7.3) μm, $L_m = 11.34$ μm, $l_m = 5.77$ μm, $Q = (1.57–)1.71–2.20(–2.27)$, $Q_m = 1.96 \pm 0.15$, ellipsoid; conspicuously roughened in profile, wall up to 0.2 μm thick; hilar appendix prominent, broad; ornamentation of complex low warts and short ridges, often in transverse orientation. **Basidia** 65–75 × 8–10 μm, clavate, attenuate below, clamped; sterigmata 4, long, straight. **Hymenium** thickening, 60–80 μm; **Subhymenium** extensive, hyphae 2–3.5 μm diam, thin-walled, clamped, hyaline, very tightly packed, interwoven, free; **Contextual hyphae**: Tramal hyphae of stipe 3–11 μm wide, hyaline, thick-walled (wall up to 2 μm thick), clamped, free interwoven; ampulliform inflations up to 12 μm broad, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed. tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, clamped, locally adherent, parallel, tightly packed; ampulliform inflations occasional, thin walled, unornamented; gloeoplerous hyphae as short, cudgel-shaped.

Ecology: Solitary or gregarious on soil in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: In southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Mouding County, Huafo Mountain, in a pine forest, altitude 2400 m, 23 August 2023, P. Zhang 5030 (MHHNU 11530); same location, brought from mushroom market, 1 August 2020, Li P. Tang Muman575 (MHKMU Muman575).

Commentary: *Ramaria robustipurpurea*, widely found in the southwestern China, is prized for its taste and popularity in the mushroom market. Traditionally known as “*Ramaria Jinzi*” in Chinese, it was previously classified under the Latin name *Ramaria mairei* Donk. To avoid confusion, the author

maintains the Chinese name “*Ramaria Jinzi*” while proposing it as a new species. Donk’s (1933) original description of *R. mairei* mentions: “Stunk kurz, wenig entwickelte; Zweige dick, ‘café au lait, subincarnat’, später blass. Spitzen mit kurzen, violett getönten Zähnen”, means “the stipe short, stout, underdeveloped, branches stout, milk cafe color, slightly red later pale, apices short, teeth-like, violet-tinted”. The description shares some similarities with *R. robustipurpurea*. However, Donk also described *R. mairei* as highly toxic: “*R. mairei* is a very poisonous mushroom. Shortly after ingestion, abdominal pain and severe diarrhea occur, but the poisoning is not fatal, and discomfort lasts at most one day”. It’s clear that the popular edible *Ramaria* in China does not match Donk’s description of *R. mairei*.

Corner’s (1950) work describes *R. mairei* with basidiomata colors ranging from lemon yellow to pale ochraceous-cream, with young branches often showing pale lilac purple at the ends, turning entirely pale ochraceous-yellow, numerous elongate branches, and a stout, pale coffee-colored stipe. Corner collected specimens not only in Europe but also in Australia, England, and other regions, noting variations in basidiomata coloration, including some with noticeable purple hues in early stages and others appear light yellow. Dr. Zhang Ping, in his 2010 description (Zhang 2010), identified a slender-stiped species collected in China as *R. mairei*, differing from Donk’s and Corner’s original descriptions. Based on molecular DNA evidence and these discrepancies, the species has been recognized as a new taxon.

Ramaria* ser. *Roseobrunneae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852721

Etymology: “*roseus*” = “pink”, “*brunneus*” = “brown”,

“*roseobrunnea*” refers to the basidiomata are pink to brown colored.

Type species: *R. roseobrunnea* P. Zhang & J. Zhong.

Diagnosis: Basidiomata brown overall, with young branches pink colored; branches crowded; basidiospores long, conspicuously roughened in profile; changes color to brownish yellow to brown on bruised; hyphae and basidia base with clamps.

Commentary: The series comprises two species collected in China.

95. *Ramaria densiapicalis* P. Zhang & J. Zhong, **sp. nov.** Fig. 34 a–b and Fig. 117

MycoBank: MB 853195

Etymology: *densiapicalis* = “dens-” + “-apicalis”, indicating that the species has crowded apices.

Diagnosis: Basidiomata are medium sized and pale yellow to cream colored; apices are crowded and concolorous with branches; basidiospores are long, slightly curved, and conspicuously roughened in profile; they change color to brownish yellow to brown upon bruising; hyphae and basidia base have clamps.

Type: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3512 (Holotype, MHHNU 10012, GenBank Acc. No.: ITS = PP467231, nrLSU = PP493543, *tef1*-α = PP480410).

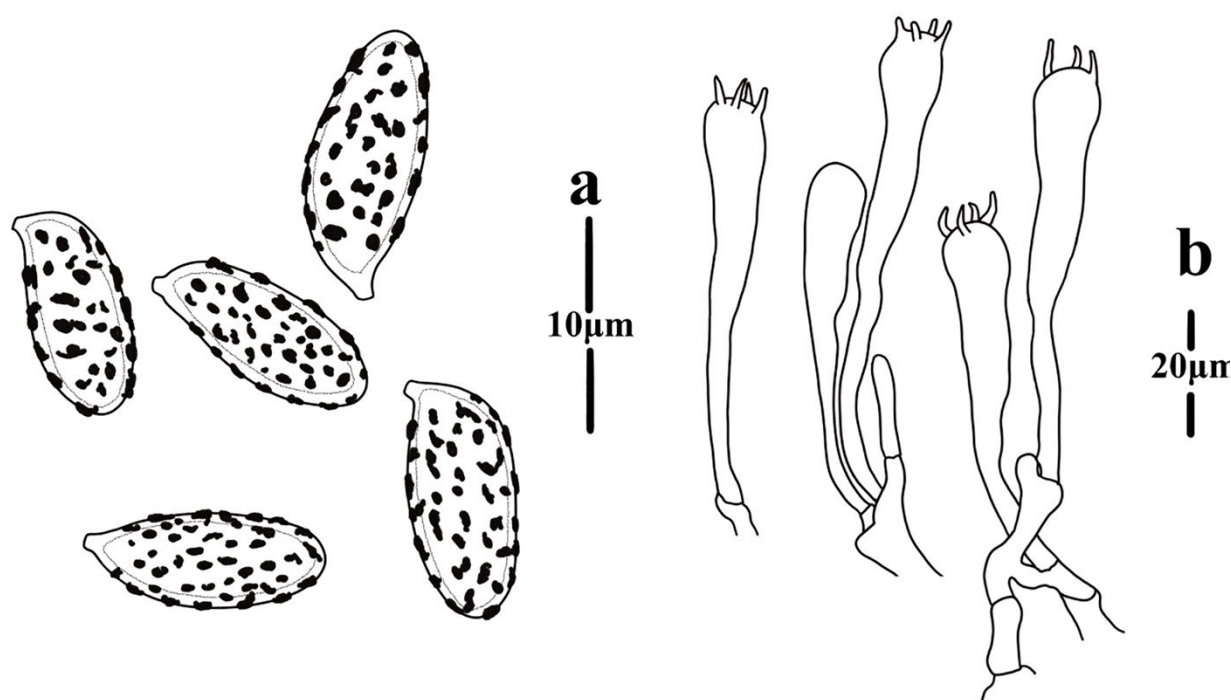


Fig. 117 Microscopic features of *R. densiapicalis* (MHHNU 10012). a basidiospores; b basidia and hymenium. Scale bars: a = 10 μm, b = 20 μm.

Description: *Basidiomata* 6–10 cm high and 5–15 cm broad, usually single to fasciculate habit. *Stipe* 2 × 1 cm, lobed to channeled, appearing fasciculate, tapering gradually downward; off-white (1A1) at base, cream (4A3) upward; changing color to brownish yellow (5B3) to brown (6E8) on bruising; surface smooth; without abortive branches; context of stipe off-white (1A1), fleshy-fibrous, occasionally hollow, drying light in weight, easily penetrated, cartilaginous. *Branches* in 3–6 ranks, major branches and branches above commonly polychotomous; inner branches and young branches pale yellow (2A3) to pale orange (5A3) when young, cream (4A3) to salmon (6A4) at age; axils narrowly rounded, mostly V-shaped; internodes all short, lower internodes up to 2 cm; branches small to large, commonly 2–8 mm, seldom over 1 cm diam, terete, crowd, subparallel, branches slightly divergent; context of main branches and upper branches fleshy-fibrous, off-white (1A1). *Apices* rounded and short, 1–3 mm long, crowded, polychotomous, slightly changing color to brownish yellow (5B3) on bruising. Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (9.1–)9.3–11.5(–12.0) ×

(3.2–)3.4–4.6(–5.3) μm, $L_m = 10.19$ μm, $l_m = 3.86$ μm, $Q = (2.05–)2.20–3.02(–3.26)$, $Q_m = 2.57 \pm 0.27$, subcylindrical; ornamented with conspicuously warts randomly placed, cyanophilous warts; hilar conspicuous, slightly curved. *Basidia* 55–80 × 8–13 μm, clavate, with basal clamps; sterigmata 2–4, mostly 4, sometimes 3, 4–7 μm long, incurved or straight, slightly divergent. *Hymenium* unthickening, 75–80 μm. *Subhymenium* extensive, 15–30 μm thick, hyphae, interwoven, 2–7 μm diam, thin-walled, with clamps. *Contextual hyphae:* Tramal hyphae of stipe 3–13 μm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 15 μm, with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 15 μm, with smooth and thin wall; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae occasionally.

Ecology: Found in a broad-leaved forest. Basidiomata occurs in summer and autumn.

Distribution: Known from northeast China and southwest China (Jilin, Xizang).

Additional material examined: CHINA, JILIN PROVINCE:

Tonghua County, Baijifeng Forest Park, in mixed forests dominated by *Acer*, *Quercus* and *Pinus*, altitude 800 m, 28 Aug. 2020, P. Zhang 4049 (MHHNU 10549).

Commentary: *Ramaria densiapicalis* typically displays colors common among *Ramaria*, ranging from yellow to salmon hues, and weakly brunnescent upon injury. Identification based only on color can be challenging due to the similarity with other species. However, morphologically, a notable characteristic of *R. densiapicalis* is the clustered stipes with individuals. Microscopically, its basidia are relatively long, and the basidiospores ornamented with conspicuously warty. *Ramaria roseobrunnea*, while similar to *R. densiapicalis* and phylogenetically closely related, is distinguished by its larger basidiospores size ($12.12 \times 4.93 \mu\text{m}$, as measured in this study).

96. *Ramaria roseobrunnea* P. Zhang & J. Zhong, **sp. nov.** Fig. 34 c–d and Fig. 118

Mycobank: MB 853100

Etymology: “*roseus*” = pink, “*brunneus*” = brown, “*roseobrunnea*” refers to the species having pink to brown-colored basidiomata.

Diagnosis: Basidiomata medium sized to large, pink to pale brown in color; apices crowded, concolorous with branches; basidiospores long, slightly curved, conspicuously roughened in profile; changes color to brownish yellow to brown on bruising; hyphae and basidia base with clamps.

Type: CHINA, HUBEI PROVINCE: Enshi, Hefeng County, Mulinzi Nature Reserve, broad-leaved forest, altitude 1300 m, 24 August 2019, Zuo H. Chen 31571 (Holotype, MHHNU 31571, GenBank Acc. No.: ITS = PP467229, nrLSU = PP493542, *tef1-a* = PP480409).

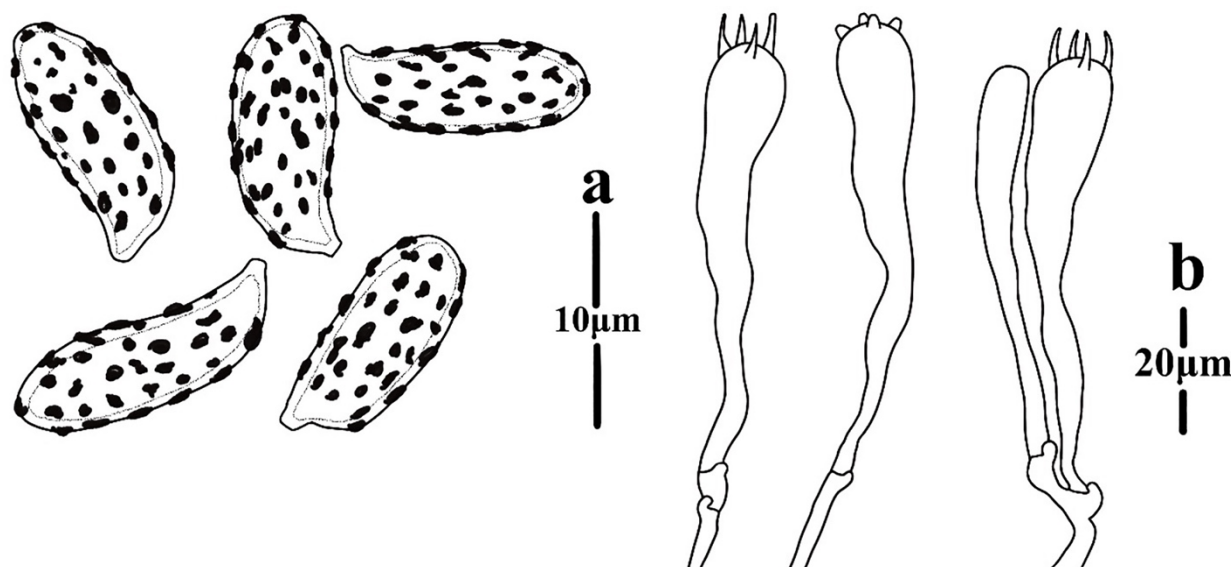


Fig. 118 Microscopic features of *R. roseobrunnea* (MHHNU 31571). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Description: Basidiomata 13 cm high and 8 cm broad, usually single to fasciculate habit. Stipe 3 $\times$ 2.5 cm, lobed or muscled; off-white (1A1) at base, cream (4A3) to grayish orange (6B5); changing color to brownish yellow (5B3) to brown (6E8) on bruising; surface tomentose, gnarled or rugose; with abortive branches; context of stipe off-white (1A1), freshy-fibrous, occasionally hollow, drying cartilaginous. Branches in 3–8 ranks, major branches and branches above commonly polychotomous; inner branches and young branches salmon (6A4) to shell pink (8A3) when young, cream (4A3) to salmon (6A4) at age; axils broadly rounded, mostly U-shaped; internodes all short, lower internodes up to 2 cm; branches small to large, commonly 3–6 mm, terete or slightly flattened, crowded, subparallel; context of main branches and upper branches freshy-fibrous, off-white (1A1). Apices rounded and short, 1–3 mm long, crowded, polychotomous, slightly changing color to brownish yellow (5B3) to brown (6E8) on bruising. Odor and taste faintly fabaceous.

Basidiospores [30/2/1] (10.8–)10.9–13.3(–13.7) $\times$ 4.3–5.7(–6.0) μm , $L_m = 12.12 \mu\text{m}$, $l_m = 4.93 \mu\text{m}$, $Q = (1.92\text{--})2.13\text{--}2.87\text{--}2.90$, $Q_m = 2.46 \pm 0.22$, subcylindrical; ornamented with conspicuously warts, cyanophilous warts; hilar conspicuous,

slightly curved. **Basidia** 55–75 $\times$ 6–13 μm , clavate, with basal clamps; sterigmata 2–4, mostly 4, 4–7 μm long, incurved or straight, slightly divergent. **Hymenium** unthickening, 75–80 μm . **Subhymenium** extensive, 15–30 μm thick, hyphae, interwoven, 2–7 μm diam, thin-walled, with clamps. **Contextual hyphae:** Tramal hyphae of stipe 3–13 μm wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 15 μm , with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 15 μm , with smooth and thin wall; ampulliform hyphae rarely; with clamps; gloeoplerous hyphae occasionally.

Ecology: Found in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: Known from central China (Hubei).

Additional materials examined: CHINA, HUBEI PROVINCE: Yichang City, Shennongjia National Nature Reserve, in a broad-leaved forest, altitude 2000 m, 3 September 2002, P. Zhang 243 (MHHNU 6743), P. Zhang 247 (MHHNU 6747).

Commentary: *Ramaria roseobrunnea* stands out distinctly among other *Ramaria* species within the genus. Initially, its young branches display a pinkish hue that matures into a creamy to light cinnamon color, with a characteristic

browning reaction upon injury. The basidiospores of *R. roseobrunnea* are notably large and feature inward-curved apices with well-defined warts. The species most closely resembling *R. roseobrunnea* in appearance is *R. patagonica* from Argentina. However, *R. patagonica* has significantly smaller basidiospores as described originally ($6.5\text{--}8 \times 4\text{--}5 \mu\text{m}$; Corner 1957). *Ramaria densiapicalis* share the closest molecular affinity with *R. roseobrunnea*, albeit with slightly smaller ($10.19 \times 3.68 \mu\text{m}$; as measured in this study).

Ramaria ser. Sanguinipesae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852718

Etymology: “Sanguis” (Latin for red) and “pes” (Latin for foot, indicating stipe) are proposed because the stipe turns red when injured.

Type species: *R. sanguinipes* R.H. Petersen & M. Zang, Acta bot. Yunn. 8(3): 289, 1986

Diagnosis: Basidiomata is pale yellow to salmon; apices or young branches yellow to red; exhibits red coloration when

injured.

Commentary: Three species of this series has been collected in China. Additionally, other species include *R. maculatipes* Marr & D.E. Stuntz, *R. vinosimaculans* Marr & D.E. Stuntz, and *R. rubribrunnescentiflava* Marr & D.E. Stuntz.

97. ***Ramaria rubriapicalis*** P. Zhang & Xue L. Gao, **sp. nov.** Fig. 35 a–b and Fig. 119

Mycobank: MB 853236

Etymology: *rubriapicalis* = “*robri*” + “*apicalis*”, proposed because the apices of the basidiomata are covered with a red color.

Diagnosis: Branches pale salmon to shell pink, with coral red apices; basidiospores large in sized, and basidia base nearly without clamps.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Chuxiong, Tuoan Township, 19 September 2022, P. Zhang 4882 (Holotype, MHHNU 11382, GenBank Acc. No.: ITS = PP467142, nrLSU = PP493469, *tef1-a* = PP480359).

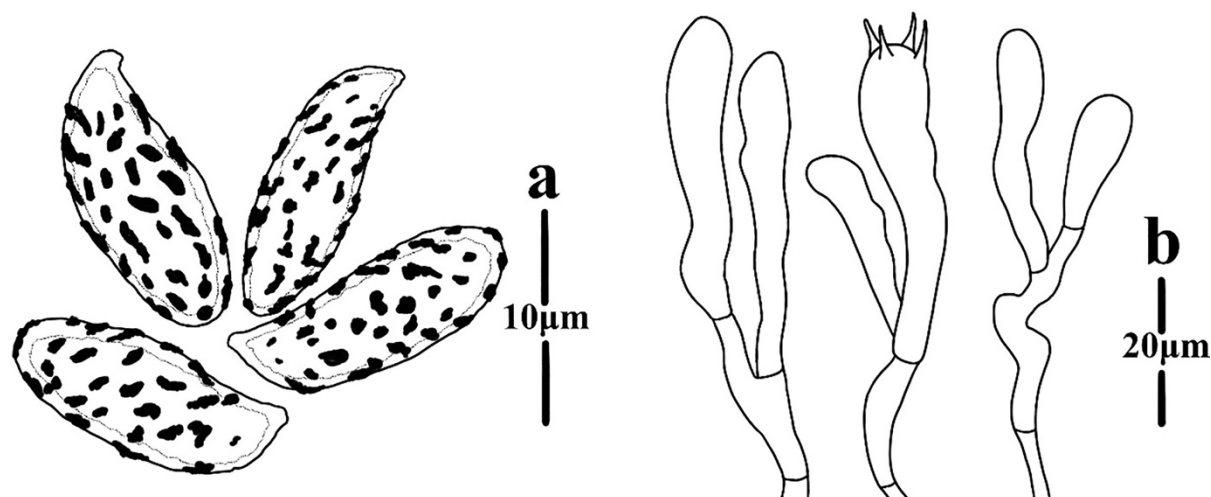


Fig. 119 Microscopic features of *R. rubriapicalis* (MHHNU 11382). a basidiospores; b basidia. Scale bars: a = 10 μm , b = 20 μm .

Description: *Basidiomata* 12 cm high and 7 cm broad, usually obpyriform in outline. *Stipe* $3.5 \times 3 \text{ cm}$, single to falsely fasciculate, fleshy, stout, tapering to rounded base, tomentose at base, smooth upward, often with abortive branches; off-white (1A1) below, salmon (6A4) to shell pink (8A3) above, very easily turned to light brown (6D6) to brownish red (11C8); flesh off-white (1A1) to shell pink (8A3), punky, but not slippery. *Major branches* several, terete, ascending, concolorous to stipe below, concolorous to branches above. *Branches* in 2–4 ranks, ascending, polychotomous, crowded; concolorous with upper major branches below, salmon (6A4) to shell pink (8A3); flesh off-white (1A1) to ivory (4B3); internodes diminishing gradually upward; axils mostly acute (V-shaped). *Apices* narrowly rounded, crowded, double-dichotomous, short-digitated by maturity, salmon (6A4), shell pink (8A3) to coral red (9B7). *Odor* negligible or faintly fresh; *taste* negligible.

Basidiospores $[60/2/2] (12.6\text{--}12.8\text{--}16.8\text{--}17.0) \times (3.7\text{--}3.8\text{--}5.1\text{--}5.4) \mu\text{m}$, $L_m = 14.22 \mu\text{m}$, $l_m = 4.41 \mu\text{m}$, $Q = (2.73\text{--}2.82\text{--}3.64\text{--}3.68)$, $Q_m = 3.24 \pm 0.23$, thick-walled, cylindrical to ellipsoid, more or less flattened adaxially, conspicuously roughened in profile; wall up to $0.5 \mu\text{m}$ thick, cyanophilous; hilar appendix prominent; ornamentation of complex

meandering and anastomosing ridges. *Basidia* $30\text{--}50 \times 6\text{--}8 \mu\text{m}$, clavate, thin-walled, hyaline, without clamps at base, 4-spored; sterigmata $5\text{--}7 \mu\text{m}$ long. *Subhymenium* rudimentary. *Hymenium* unthickening. *Tramal hyphae of stipe* $3\text{--}15 \mu\text{m}$ wide, hyaline, thin-walled, virtually unclamped, interwoven; ampulliform clamps up to $14 \mu\text{m}$ broad, gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* $4\text{--}10 \mu\text{m}$ wide, hyaline, thin-walled, interwoven, loosely parallel, occasionally clamped; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved and coniferous mixed forests; basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Kunming, bought from mushroom market, 23 July 2017, P. Zhang 2597 (MHHNU 9097); Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved and coniferous mixed forest, altitude 2400 m, 23 August 2022, P. Zhang 4768 (MHHNU 11268); same city, Shuangbai County, 22 August 2018, Zuo H. Chen 31297 (MHHNU 31297); Nanhua County, bought from mushroom market, 9 August 2016, P. Zhang 2384 (MHHNU 8884); same location, Yulu Township, in broad-leaved forest, altitude 2000 m, 10 August 2016, P. Zhang 2393

(MHHNU 8893) and P. Zhang 2394 (MHHNU 8894).

Commentary: *Ramaria botrytoides* and *R. coulterae* Scates bear a striking resemblance to species within the *R. rubriapicali*. While *R. botrytoides* shares a similar apices color with *R. rubriapicali*, the *R. botrytoides* is distinguished by its shorter basidiospores ($L_m = 8.44 \mu\text{m}$; Corner 1950). *Ramaria rubriapicali* may also be mistaken for *R. coulterae*, but the latter species features a single stipe with a brown band in radial section, shorter basidiospores ($L_m = 9.95 \mu\text{m}$; Petersen & Scates 1988), and a spring fruiting pattern. *Ramaria rubriapicali* is also phylogenetically close to *R. sanguinipes*, however, the former has pale yellow to yellow basidiomata, whereas the latter displays a whitish to creamy coloration.

98. *Ramaria rubriattenuipes* R.H. Petersen & M. Zang, Acta bot. Yunn. 11(4): 392, 1989. Fig. 35 c–d and Fig. 120

Description: Basidiomata 16 cm high and 6 cm broad, fusiform to broadly fusiform in outline. Stipe $5 \times 2.4 \text{ cm}$, tapering gradually downward, usually attenuate, rooting, often with abortive branches, single, off-white, significantly rubescent over large areas to dark red to maroon; flesh off-white, solid, not slippery, drying light in weight and easily penetrated. Major branches 3–5, curved-ascending, terete, butter yellow to off-white. Branches in 4–6 ranks, cream to dull yellow when flesh, often strained maroon in blotches, in age butter yellow; internodes diminishing gradually upwards at maturity; axils narrowly rounded. Apices fine, delicate, slightly divergent when young, blunt, digitate to mitten-shaped in age, pale yellow when young or flesh, in age sometimes mustard yellow. Odor faintly fragrant to middle fresh; taste negligible.

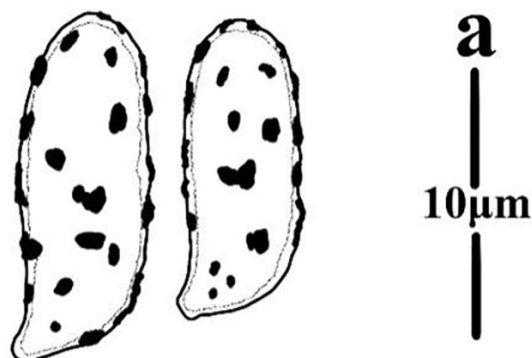


Fig. 120 Basidiospores of *R. rubriattenuipes* (MHHNU 6578). Scale bar: a = $10 \mu\text{m}$.

Basidiospores [30/2/2] $11.5\text{--}15.8 \times 4.7\text{--}5.4 \mu\text{m}$, $L_m = 13.43 \mu\text{m}$, $l_m = 4.99 \mu\text{m}$, $Q = 2.27\text{--}3.00$, $Q_m = 2.69$, ellipsoid to subcylindrical, conspicuously roughened in profile; wall up to $0.2 \mu\text{m}$ thick, cyanophilous; hilar appendix broad, truncate; ornamentation of anastomosing ridges and discrete, plate-like warts; struma not observed. Basidia $75\text{--}92 \times 11\text{--}13 \mu\text{m}$, clavate, without clamps; sterigmata 4, stout, straight. Hymenium thickening. Tramal hyphae of stipe $4\text{--}13 \mu\text{m}$ wide, hyaline, without clamps, thin to thick walled (wall up to $1 \mu\text{m}$ thick), interwoven, tightly packed, not agglutinated or adherent; ampulliform clamps up to $14 \mu\text{m}$ broad, blunt, not unusually thick-walled, with extensive, coarse, stalactitiform ornamentation, often not inflated or slightly so; gloeoplerous hyphae not observed. Tramal hyphae of upper branches $5\text{--}14 \mu\text{m}$ wide, hyaline, without clamps, thick-walled (wall up to 1

μm thick), usually inflated, parallel, not agglutinated or adherent, tightly packed; ampulliform swellings not observed; gloeoplerous hyphae hardly discernable, moderately cyanophilous.

Ecology: Solitary or gregarious on soil in high-altitude forests with *Pinus yunnanensis*; basidiomata occurring in autumn.

Distribution: Known from southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang City, Tiejia Mountain, in a forest with *Pinus yunnanensis*, altitude 2800 m, 31 July 2001, P. Zhang 78 (MHHNU 6678); same city, Yulong Snow Mountain, in a forest with *Pinus yunnanensis*, altitude 3400 m, 10 August 2008, Li P. Tang 78 (HKAS 54802).

Commentary: *Ramaria rubriattenuipes* resembles *R. sanguinipes*, both of which inhabit the same region and exhibit reddening stipes. However, *R. sanguinipes* possesses clamps. Another comparable species, *R. xanthosperma*, found in the eastern United States, shares similarities with *R. rubriattenuipes* (Corner 1950). For further comparisons with other similar species, please refer to the discussion section of the *R. sanguinixantha*.

99. *Ramaria sanguinipes* R.H. Petersen & M. Zang, Acta bot. Yunn. 8(3): 289, 1986. Fig. 35 e–f and Fig. 121

Basionym: *Ramaria pseudovinosimaculans* P.R. Biswas & A.K. Dutta, Phytotaxa: 659(1):77–86. (Biswas et al. 2024)

Description: Basidiomata 6 cm high and 5 cm broad, curved-obovate to generally circular in outline. Stipe $3 \times 3 \text{ cm}$, single or fasciculate, stout, smooth to somewhat marbled, off-white to ivory-colored, not canescent, often with aborted branchlets, rounded at base, tapering sharply downward, watery brunnescent, stained dark red to maroon red at base, and suffused in this color upward; flesh solid, dry, punky, marbled, brownish red under stained surface. Major branches several, short when young, lengthening significantly over time, ivory-colored; Branches in 3–6 ranks, abruptly short than major branches, ivory-colored below, butter yellow upward, eventually fading to dull yellow; internodes diminishing abruptly above in adolescence, less so at maturity; axils narrowly rounded. Apices slender, small, not terraced at any age, somewhat divaricate in some specimens, dichotomous, pale yellow. Odor weakly aromatic; taste mildly fabaceous.

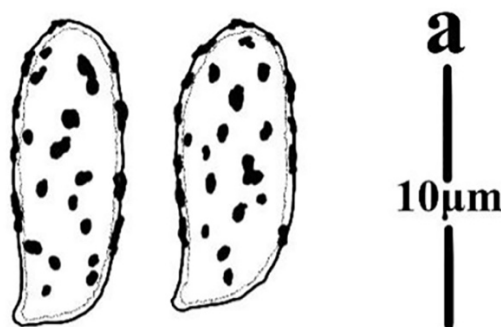


Fig. 121 Basidiospore of *R. sanguinipes* (MHHNU 11250). Scale bar: a = $10 \mu\text{m}$.

Basidiospores [31/2/2] $10.0\text{--}13.0\text{--}(13.5) \times 4.0\text{--}5.2\text{--}(6.0) \mu\text{m}$, $L_m = 11.02 \mu\text{m}$, $l_m = 4.50 \mu\text{m}$, $Q = (2.20\text{--})2.22\text{--}2.67\text{--}(2.74)$, $Q_m = 2.45 \pm 0.13$, ellipsoid to narrowly ovate, often rough in profile; wall up to $0.3 \mu\text{m}$ thick; hilar appendix small but conspicuous;

ornamentation of cyanophilous, complex, anastomosing ridges. *Basidia* 40–45 × 8–10 µm, clavate, clamped invariably; sterigmata 4, straight, somewhat divergent. *Subhymenium* extensive, hyphal. *Hymenium* thickening. *Tramal hyphae* of *stipe* 14 µm wide, hyaline, thin-walled to locally somewhat thick-walled (wall up to 0.5 µm thick), virtually unclamped, not parallel, not agglutinated or adherent. *Tramal hyphae* of *upper branches* up to 10 µm wide, hyaline, thin-walled, parallel; clamps occasional on medullary hyphae, common on cortical hyphae.

Ecology: Found in mixed forests dominated by Fagaceae and Pinaceae. Basidiomata occurring in autumn.

Distribution: Known from south and southwestern China (Yunnan, Xizang, Hainan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Lijiang, Lijiang market, 6 September 1983, no. 21308 (TENN, HKAS: 20080); same city, Yulong Snow Mountain, in a forest with *Pinus yunnanensis*, altitude 3200 m, 21 July 2008, Li P. Tang 420 (HKAS 54651); Simao, 20 September 1983, no. 45677 (Holotype, TENN; isotype, HKAS: 10418); Kunming, bought from mushroom market, 2 October 2006, P. Zhang 576 (MHHNU 7076) and 23 July 2017, P. Zhang 2599 (MHHNU 9099); Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 2 August 2001, P. Zhang 86 (MHHNU 6586) and P. Zhang 93 (MHHNU 6593); same location, 3 August 2001, P. Zhang 122 (MHHNU 6622); same city, Shuangbai County, 22 August 2018, Zuo H. Chen 31296 (MHHNU 31296); same city, Mouding County, Huafo Mountain, altitude 2400 m, 23 August 2018, Zuo H. Chen 31330 (MHHNU 31330); Nanhua County, Yulu Township, in broad-leaved forest, altitude 2000 m, 10 August 2016, P. Zhang 2391 (MHHNU 8891) and P. Zhang 2392 (MHHNU 8892); same location, 21 August 2018, Zuo H. Chen 31269 (MHHNU 31269) and Zuo H. Chen 31273 (MHHNU 31273); same location, Sapiwu Village, with broad-leaved, coniferous or mixed forests, altitude 2000 m, 22 August 2022, P. Zhang 4750 (MHHNU 31269) and P. Zhang 4753 (MHHNU 31263); same location, with coniferous forests, altitude 1800 m, 22 August 2023, P. Zhang 5017 (MHHNU 11517); Pu'er, Lancang County, Ankang Township, in a forest dominated by Pinaceae, altitude 1610 m, 28 July 2017, P. Zhang 2619 (MHHNU 9119); Menglang Town, brought from mushroom market, 30 July 2017, P. Zhang 2627 (MHHNU 9127) and P. Zhang 2633 (MHHNU 9133); Dali, Binchuan

County, Jizu Mountain, with broad-leaved, coniferous or mixed forests, altitude 2300 m, 29 August 2022, P. Zhang 4822 (MHHNU 11322). XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3555 (MHHNU 10055).

Commentary: The species within *Ramaria* exhibiting a red stain both on the stipe surface and in the context appears globally distributed. Among the species described, five have clamps while six lack them. The discussion of these eleven species can be found in the discussion section of the *R. sanguinixantha*.

***Ramaria* ser. *Semigelatinosae* P. Zhang & J. Zhong, ser. nov.**

Mycobank: MB 852770

Etymology: “*semigelatinosa*” refers to the basidiomata having branches that are semi-gelatinous in context.

Type species: *R. semigelatinosa* P. Zhang & J. Zhong.

Diagnosis: Basidiomata elongate, salmon-color; apices broadly acute, concolorous with branches; branches not crowded, flesh red orange; basidia base and hyphae typically lack clamps; basidiospores slightly rough, short and broad.

Commentary: This series, collected exclusively in China, consists of a single species distinguished by its small-sized basidiomata, red-orange coloration, gelatinous flesh in the branches, fleshy context in the stipe, and presence of clamps at the basidia base.

100. ***Ramaria semigelatinosa* P. Zhang & J. Zhong, sp. nov.** Fig. 36 a–b and Fig. 122

Mycobank: MB 853202

Etymology: “*semigelatinosa*” means the specie has a semi-gelatinous context in its stipe.

Diagnosis: Basidiomata elongate, salmon to orange in color; apices broadly acute, concolorous with branches; branches not crowded, flesh pale orange; basidia base and hyphae typically lacking clamps; basidiospores slightly rough, short and broad.

Type: CHINA, YUNNAN PROVINCE: Dali, Binchuan County, Jizu Mountain, with broad-leaved, coniferous or mixed forests, altitude 2300 m, 29 August 2022, P. Zhang 4810 (Holotype, MHHNU 11310, GenBank Acc. No.: ITS = PP467309, nrLSU = PP493607, *tef1-a* = PP480461).

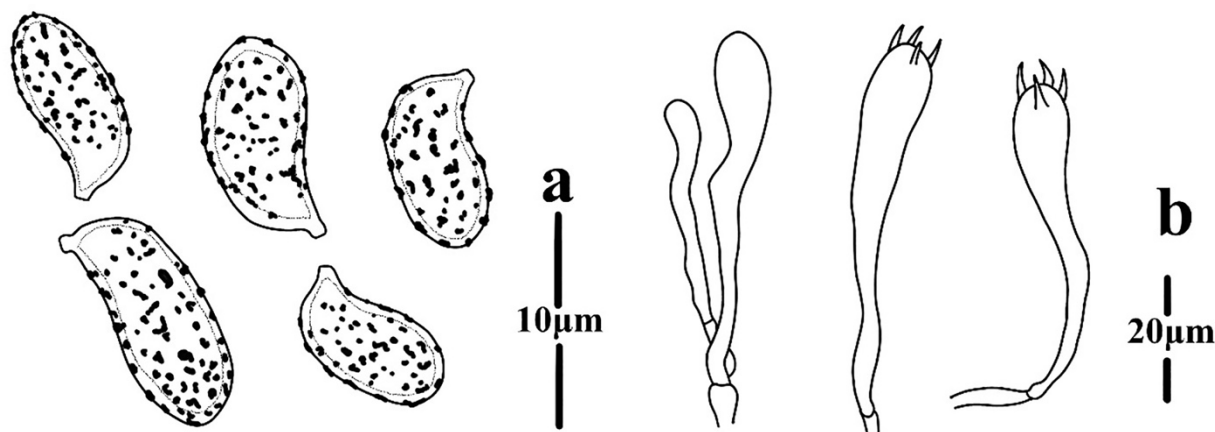


Fig. 122 Microscopic features of *R. semigelatinosa* (MHHNU 11310). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 6 cm high, up to 4 cm broad, linear, elongate obpyriform in outline. *Stipe* 1 × 1 cm, falsely fasciculate, smooth, with 1–2 abortive branchlets high on stipe, smooth, very clean, off-white (1A1) at base, pale orange (5A3) to yellowish orange (4A8) color, not changing color on bruising; flesh off-white (1A1), fibrous, moist but not slippery or gelatinous. *Major branches* 2–4, ascending, terete, concolorous with branches; flesh pale orange (5A3) near hymenium when young; *Branches* 2–3 ranks, dichotomous, not crowded, terete, strict, pale salmon (6A4); flesh darker, nearly apricot yellow (5B6); internodes long, diminishing gradually upward; axils broadly rounded (U shaped); *Apices* broadly rounded, stiffly digitate, double-dichotomous, pale orange (5A3) or concolorous with branches. Taste and odor not recorded.

Basidiospores [60/2/2] (7.2–)8.2–11.0(–11.7) × (3.6–)3.8–5.7(–6.0) µm, $L_m = 9.65$ µm, $l_m = 4.15$ µm, $Q = (1.53–)1.77–2.34(–2.61)$, $Q_m = 2.05 \pm 0.21$, ellipsoid to cylindrical, slightly roughened in profile; hilar appendix prominent, beaklike; ornamentation of small warts and curved ridges randomly placed. *Basidia* 45–60 × 8–9 µm, clavate, without clamps, crowded; sterigmata 4, slender and straight. *Subhymenium* rudimentary, pseudo-parenchymatous. *Hymenium* thickening. *Tramal hyphae of stipe* 5–18 µm wide, hyaline, stiff, loosely parallel, usually without clamps, not agglutinated or adherent; ampulliform clamps not observed; gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* 5–16 µm wide, hyaline, inflated, usually without clamps, secondarily septum, loosely parallel, not agglutinated or adherent; ampulliform clamps not observed; gloeoplerous hyphae occasionally observed.

Ecology: Solitary or gregarious in broad-leaved, coniferous, or mixed forests. Basidiomata occur in autumn.

Distribution: Known from southwestern China (Yunnan) and central China (Hubei).

Additional materials examined: CHINA, YUNNAN PROVINCE: Dali, Binchuan County, Jizu Mountain, with broad-leaved, coniferous or mixed forests, altitude 2300 m, 29 August 2022, P. Zhang 4811 (MHHNU 11311), P. Zhang 4812 (MHHNU 11312), P. Zhang 4827 (MHHNU 11327), P. Zhang 4834 (MHHNU 11334); Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 3 August 2001, P. Zhang 117 (MHHNU 6617). HUBEI PROVINCE: Enshi, Hefeng County, Wuyang Township, Hewan Village, altitude 1000 m, 24 September 2019, Zuo H. Chen 31723 (MHHNU 31723).

Commentary: In Dr. Zhang's postdoctoral thesis (Zhang 2010), he identified this species as *R. linearioides*. The basidiospores size of *R. semigelatinosa* is not significantly different from that of *R. linearioides*, and both exhibit clamps. However, phylogenetic analyses indicate that *R. semigelatinosa* and *R. linearioides* are distantly related, despite their morphological resemblance. In addition, Petersen's 1989 publication described *R. linearioides* as nearly indistinguishable from *R. lineari* R.H. Petersen & M. Zang in appearance (Petersen & Zang 1989). Both have slender basidiomata, salmon-yellow branches, amyloid stipe flesh, and *R. linearioides* was noted to have abortive branches on the stipe. With the collection of more basidiomata, it was observed that *R. semigelatinosa* has small fruiting bodies and usually lacks abortive branches, and the branches are not slender. Additionally, the apices are broadly rounded and not awl shaped as described by

Petersen, leading to the identification of this species as a new one.

***Ramaria ser. Sparsiaggregatae* P. Zhang & J. Zhong, ser. nov.**

MycoBank: MB 853515

Etymology: *sparsiaggregata* = “*sparsi-*” + “*aggregate*”, refers to the species have sparse branches and with fasciculate habit.

Type species: *R. sparsiaggregata* P. Zhang & J. Zhong

Diagnosis: Gregarious habit; basidiomata small to medium sized, dark yellow in color; stipe flesh tough; basidiospores small and broadly ($L_m < 10$ µm), with small warts; hyphae and basidia base lacking clamps; No color change upon bruising.

Commentary: This series exclusively collected in China, consists of a single species, characterized by its overall yellow basidiomata, tough flesh, and solitary to gregarious habit.

101. ***Ramaria sparsiaggregata* P. Zhang & J. Zhong, sp. nov.** Fig. 37 a–b and Fig. 123

MycoBank: MB 853313

Etymology: *sparsiaggregata* = “*sparsi-*” + “*aggregate*”, referring to the species having sparse branches and with a fasciculate habit.

Diagnosis: Basidiomata are small-sized, ranging from orange to light brown in color; apices are rounded, dichotomous, yellow, or concolorous with branches; basidiospores are cylindrical to slightly ellipsoidal and somewhat rough; no color change upon injury to basidiomata; basidia base and hyphae lack clamps.

Type: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3516 (Holotype, MHHNU 10016, GenBank Acc. No.: ITS = PP467228, nrLSU = PP493541, *tef1-α* = PP480408).

Description: *Basidiomata* 5–8 cm high and 1–3 cm broad, usually fasciculate habit. *Stipe* 0.3–0.6 × 0.5–2.5 cm, rarely single, clustered together at base, flatten due to hollow flesh, tapering gradually downward, or branching directly from the ground; surface pale yellow (5A3) to salmon (6A4); not changing color on bruising; surface tomentose; without abortive branches; context of stipe paler than hymenium when fresh, off-white (1A1), fleshy-fibrous, occasionally hollow, drying cartilaginous. *Branches* in 3–6 ranks, major branches and branches above commonly polychotomous; yellowish orange (4A8) when young, cream to mustard yellow (4A3–3B6) at age; axils narrowly rounded to broadly round, mostly U-shaped; internodes diminishing gradually at maturity, lower internodes up to 4 cm; branches slender, commonly 3–5 mm, seldom over to 1 cm, flattened, sparse, subparallel; context of main branches fleshy-fibrous, off-white (1A1), context of upper branches fleshy-fibrous, off-white (1A1) to pall orange (5A3), bruising or staining reactions entirely absent. *Apices* broadly rounded, 1–3 mm long, dichotomous, pastel yellow (2A4). Odor and taste faintly fabaceous.

Basidiospores [60/2/2] (7.5–)8.0–9.7(–10.1) × (4.1–)4.4–5.8(–6.0) µm, $L_m = 8.93$ µm, $l_m = 4.99$ µm, $Q = (1.50–)1.59–2.02(–2.39)$, $Q_m = 1.80 \pm 0.15$, ovate to shortly ellipsoidal; finely ornamented with linearly lobed, cyanophilous warts; hilar appendix small but conspicuous. *Basidia* 40–65 × 8–12 µm,

clavate, without clamps at base; sterigmata 2–4, mostly 4, 3–7 μm long, incurved or straight, slightly divergent, occasionally two sterigmata connate at base. *Hymenium* unthickening, 70 μm . *Subhymenium* extensive, 20–30 μm thick, hyphae, interwoven, 2–5 μm diam, thin-walled, without clamps. *Contextual hyphae*: Tramal hyphae of stipe 5–12 μm

wide, hyaline, loosely interwoven, inflating slightly, terminal swollen hyphae wide to 13 μm , with moderately ornamented; tramal hyphae of branches central hyphae slightly lysing, terminal swollen hyphae wide to 13 μm , with smooth and thin wall; ampulliform hyphae rarely; without clamps; gloeoplerous hyphae occasionally.

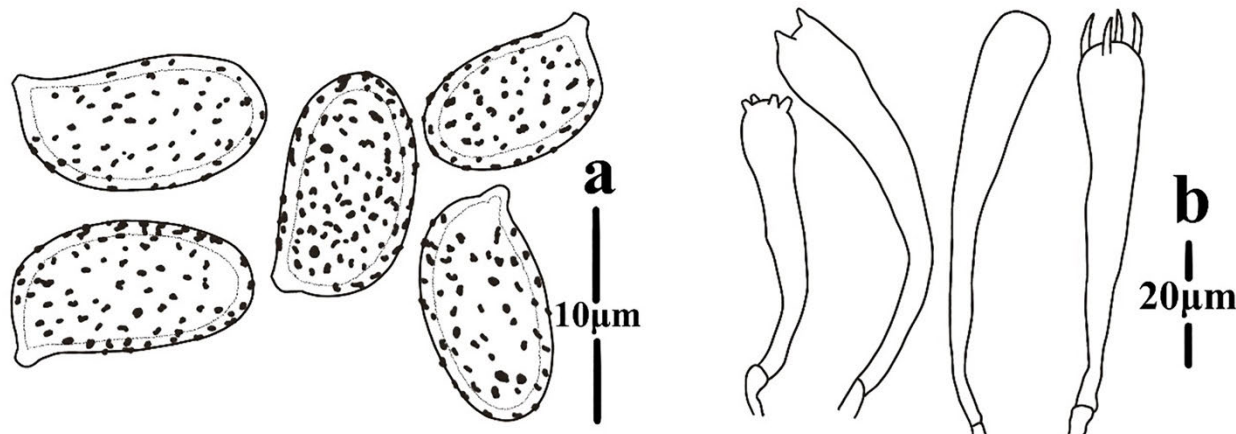


Fig. 123 Microscopic features of *R. sparsiaggregata* (MHHNU 10016). a basidiospores; b basidia. Scale bars: a =10 μm , b = 20 μm .

Ecology: Found in mixed forests with *Quercus* and *Picea*. Basidiomata occurs in summer and autumn.

Distribution: Known from southwestern China (Xizang, Yunnan).

Additional materials examined: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3517 (MHHNU 10017). Shangri-La City, Pudacuo National Park, Tianbaotai, in the mixed forest with *Quercus* and *Picea*, altitude 3700 m, 1 September 2022, P. Zhang 4863 (MHHNU 11363).

Commentary: *Ramaria sparsiaggregata* shares a close phylogenetic relationship with the composite group known as *R. conjunctipes* or ser. *Conjunctipesae*, which includes species with an average basidiospores length greater than 8 μm such as *R. conjunctipes*, *R. ignicolor*, *Ramaria lorithamnus* (Berk.) R.H. Petersen, *R. petersenii*, and *R. raveneliana*. Among these, the most similar species to *R. sparsiaggregata* is *R. lorithamnus* from Australia, distinguished by its overall yellow to mustard-yellow basidiomata color, which contrasts with the salmon or yellow hues observed in other species (Petersen 1982). *Ramaria conjunctipes* occasionally features hollow branches with gelatinous flesh, *R. ignicolor* is exclusively found in Europe with a pinkish basidiomata hue, *R. petersenii* has solitary stipes rather than fasciculate ones, and *R. raveneliana*, found in the eastern United States, exhibits an average basidiospores length of 9.94 μm (Petersen 1982).

In China, *R. sinoconjunctipes* is the only species reported within the ser. *Conjunctipesae*. It is distinguished by its larger basidiospores with a greater length-to-width ratio, basidiomata color leaning towards a darker yellow without pinkish tones, and broadly rounded apices. Our two-gene molecular phylogeny confirms the distinctiveness of *R. sparsiaggregata* from other species within ser. *Conjunctipesae*.

Ramaria* ser. *Spinulosae (Franchi & M. Marchetti) P. Zhang & J. Zhong, **stat. nov.**

Synonym: *Ramaria* sect. *Spinulosae* Franchi & M. Marchetti, *Fungi Non Delineati*, *Raro vel Haud Perspecte et Explorate Descripti aut Definite Picti* 16: 39 (2001).

Type species: *R. spinulosa* (Pers.) Quél., *Fl. mycol.* France (Paris): 468 (1888).

Diagnosis: basidiomata are purple with brown tone; change color to vinous (wine-red to purplish red) when bruised or injured; basidia base and hyphae lack clamps; basidiospores are conspicuously rough, short, and broad.

Commentary: This series of *Ramaria* species has been collected in China and comprises three distinct taxa. Additionally, other notable species in this group include *R. brunneolilacina* Franchi & M. Marchetti, *R. spinulosa* (Pers.) Quél. and its variety *R. spinulosa* var. *diminutiva*, as well as *R. intemorosea* Schild & Vrscaj. These species exhibit various shades of purple and are characterized by the absence of clamps in their basidia base and hyphae.

102. ***Ramaria purpurea*** P. Zhang & J. Zhong, **sp. nov.** Fig. 38 a–b and Fig. 124

Mycobank: MB 853172

Etymology: “*purpurea*” refers to the basidiomata having grayish purple and purple-brown colors.

Diagnosis: Young basidiomata are purple, aging to gray tone; apices are white grayish or concolorous with branches; basidia base lacks clamps, and hyphae typically lack clamps; basidiospores are slightly rough, short, and broad.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved and coniferous mixed forest, altitude 2400 m, 23 August 2022, P. Zhang 4767 (Holotype, MHHNU 11267, GenBank Acc. No.: ITS = PP467303, nrLSU = PP493601).

Description: *Basidiomata* 6–6.5 cm high, up to 3.5–4 cm broad, superficially obconical to trumpet-shaped in outline. *Stipe* 1 × 4 cm, single to falsely fasciculate, minutely tomentose and off-white (1A1) below substrate, smooth and flesh (6B3) above, becoming lilac gray (15B2) to purplish gray (14D2) in age; surface obviously weakly brunnescent where handled; flesh white (1A1), fibrous-fleshy, moist but not

slippery or gelatinous, not changing color on bruising. *Branches* few per fascicle, often terete or flattened, flesh (6B3) when young, lilac gray (15B2) at age; flesh cream (4A3) near hymenium; surface brunnescent when injury; axils narrowly rounded to acute when young, often lunate in age; internodes

diminishing gradually upward, giving an open, lax appearance. *Apices* short and straight, dichotomous, lilac gray (15B2) and finally concolorous with branches. Taste and odor not recorded.

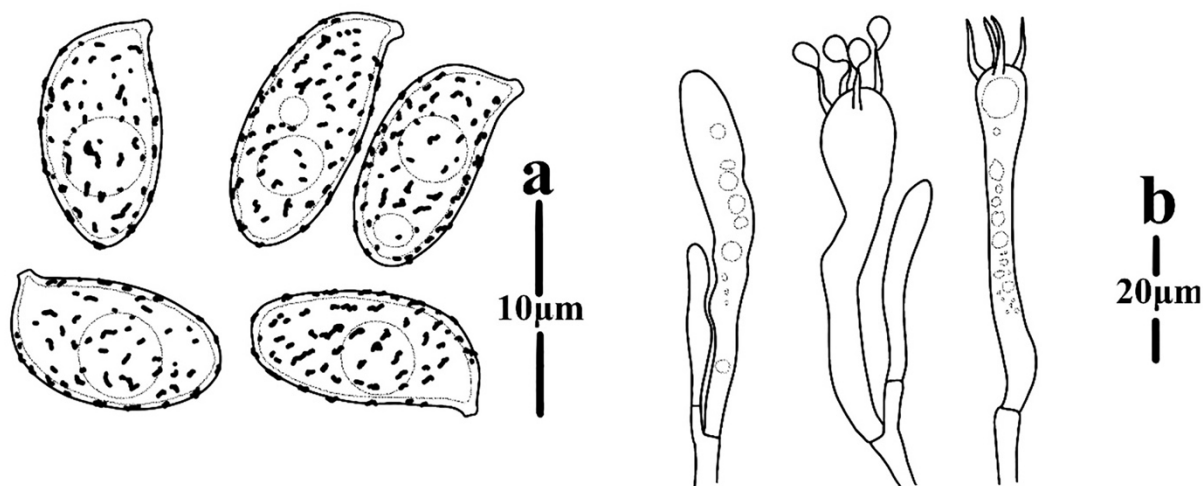


Fig. 124 Microscopic features of *R. purpurea* (MHHNU 11267). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Basidiospores [60/2/2] (8.5–)8.9–11.5(–12.5) × (3.8–)4.2–5.6(–5.8) μm, $L_m = 10.01$ μm, $l_m = 4.89$ μm, $Q = (1.69)1.73$ –2.55(–2.72), $Q_m = 2.08 \pm 0.22$, cylindrical, obscurely undulate in profile; wall up to 0.2 μm thick; hilar appendix truncates, somewhat prominent, abrupt; ornamentation of small warts randomly placed. **Basidia** 48–65 × 7–13 μm, clavate, without clamped; sterigmata 4, long, spindly, slightly curved. **Hymenium** unthickening. **Tramal hyphae of stipe** 8–13 μm, hyaline, thin-walled, without clamped, not agglutinated or adherent, of two types hyphae: 1) 8–13 μm wide, parallel, somewhat inflated; and 2) dendrohyphidia hyphae, tortuous, often with abundant side branches and usually ending as abortive pegs or short branches, without clamp. **Stipe surface hyphae** identical to predominant flesh hyphae. **Tramal hyphae of upper branches** 7–13 μm wide, thin-walled, parallel, almost always clampless, hyaline, without branches or free branches.

Ecology: Solitary or gregarious in forests dominated by *Picea yunnanensis* or in broad-leaved and coniferous mixed forests. Basidiomata occurs in summer and autumn.

Distribution: known from southwestern China (Yunnan).

Additional material examined: CHINA, YUNNAN PROVINCE: Dali, Dali City, Xianyangfeng, in a forest dominated by *Picea yunnanensis*, altitude 2800 m, 12 August 2018, P. Zhang 3379 (MHHNU 9879).

Commentary: *Ramaria purpurea* shares similarities with *R. spinulosa*, both possessing purplish-gray basidiomata, lacking clamps, and featuring slightly roughened basidiospores. The distinguishing feature lies in the longer and wider basidiospores of the latter ($L_m = 10.47$ μm, $l_m = 5.37$ μm, Petersen RH 1985). *Ramaria purpurea* also bears resemblance to the purplish-brown species *Gomphus asiaticus*, but the latter possesses clamps. Among *Ramaria* found in China, those with purplish basidiomata can be classified into two major groups: one with clamps and the other lacking clamps. The group with clamps tends to exhibit more pronounced basidiospores ornamentation, while the group

lacking clamps only displays slight roughening of basidiospores.

103. *Ramaria purpureivariabilis* P. Zhang & J. Zhong, **sp. nov.** Fig. 38 c–d and Fig. 125

Mycobank: MB 853171

Etymology: *purpureivariabilis* = *purpurea* + *variabilis*, is proposed because this species changes color to purple when damaged or aged.

Diagnosis: basidiomata ranges from light brownish cream to dark yellow; apices change color to deep purplish gray to grayish magenta when injured or aging; 3) hyphae and basidia base lack clamps; basidiospores are short, broadly shaped, and rough in outline.

Type: CHINA, HUBEI PROVINCE: Enshi, Hefeng County, Wuyang Township, Hewan Village, in a broad-leaved forest, altitude 1000 m, 24 September 2019, Zuo H. Chen 31737 (Holotype, MHHNU 31737, GenBank Acc. No.: ITS = PP467302, nrLSU = PP493600, *tef1-α* = PP480458).

Description: **Basidiomata** 10 cm high, up to 6.5 cm broad, usually obovate in outline. **Stipe** 3 × 2 cm, single, off-white (1A1), tomentose at base, smooth above, tapering gradually downward, with no abortive branchlets, slowly brunnescent when handled or chaffed; flesh white (1A1), solid, fibrous-fleshy, moist but not slippery or gelatinous. **Major branches** 3, terete, dull yellow (3B3), cream (4A3) to dull yellow (3B3) upward. **Branches** 3–4 ranks, terete, concolorous with main branches below, dull yellow (3B3) to purplish gray (14D2) upward; flesh off-white (1A1), surface turned to purplish gray (14D2) to grayish magenta (13D5); internodes diminishing gradually upward; axils narrowly rounded or rounded (both “V” shape and “U” shape). **Apices** acute, double-dichotomous, grayish magenta (13D5). Taste and odor are negligible.

Basidiospores [60/1/1] (8.0–)8.4–10.3(–10.7) × (3.9–)4.3–5.6(–5.9) μm, $L_m = 9.20$ μm, $l_m = 4.97$ μm, $Q = (1.50)1.54$ –2.22(–2.39), $Q_m = 1.50 \pm 0.19$, cylindrical, rough in profile; hilar appendix truncates, somewhat prominent; ornamentation of

small warts and short ridges randomly placed. *Basidia* 30–50 × 5–9 µm, clavate, without clamps; sterigmata 4, stout and straight. *Subhymenium* rudimentary, hyphal. *Hymenium* unthickening. *Tramal hyphae of stipe* 3–11 µm wide, hyaline, interwoven, thin-walled to thick-walled, without clamps, not agglutinated or adherent; ampulliform clamps not observed;

gloeoplerous hyphae not observed. *Tramal hyphae of upper branches* 3–9 µm wide, hyaline, thin-walled to thick-walled, absent clamps, secondarily septum, parallel, not agglutinated or adherent; ampulliform clamps not observed; gloeoplerous hyphae not observed.

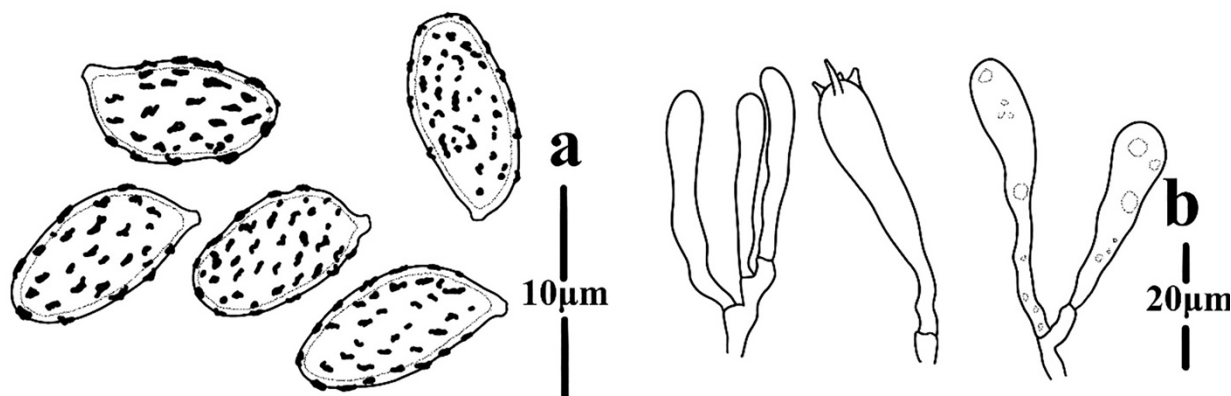


Fig. 125 Microscopic features of *R. purpureivariabilis* (MHHNU 31737). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Ecology: Solitary in broad-leaved forests. Basidiomata occurs in summer and autumn.

Distribution: known from central China (Hubei).

Commentary: *Ramaria purpureivariabilis* exhibits the lowest Q-value (length-to-width ratio of basidiospores) among the purplish species of *Ramaria* collected in China that lack clamps. The main color of this species ranges from flesh to cream, with a purplish tint primarily near the apices. Similar species to *R. purpureivariabilis* include *R. purpurea* (basidiospore 10.01 × 4.89 µm, as measured in this study) and *R. sinospinulosa* (basidiospore 11.38 × 5.62 µm, as measured in this study), all of which share similar basidiomata coloration and lack clamps. However, the other two species have been reported from southwestern China, where the purplish hue is more pronounced, with slightly larger average basidiospores length and Q-values.

104. *Ramaria sinospinulosa* P. Zhang & J. Zhong, **sp. nov.** Fig. 38 e–f and Fig. 126

Mycobank: MB 853173

Etymology: *sinospinulosa* = *sino* + *spinulosa*, referring to the species collected in China and its similarity to *R. spinulosa*.

Diagnosis: Basidiomata are purple with brown tone; apices are broadly acute and concolorous with branches; changes color to vinaceous on bruising or handling; basidia base hyphae lack clamps; basidiospores are conspicuously rough, short and broad.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea*, altitude 3900 m, 6 September 2021, P. Zhang 4288 (Holotype, MHHNU 10788, GenBank Acc. No.: ITS = PP467305, nrLSU = PP493603, *tef1*-α = PP480459).

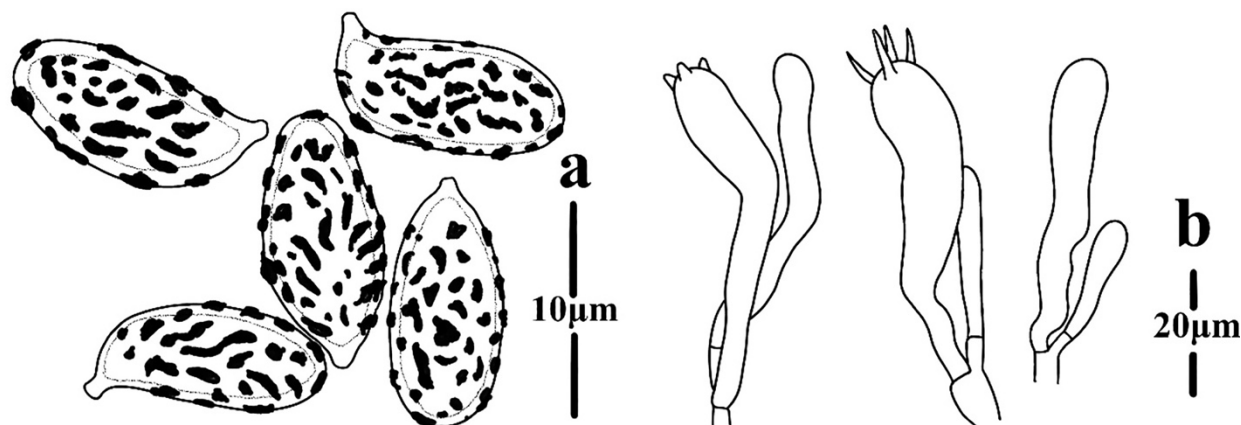


Fig. 126 Microscopic features of *R. sinospinulosa* (MHHNU 10788). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 14 cm high, up to 15 cm broad, superficially obconical to trumpet-shaped in outline, but old

basidiomata becoming lax. *Stipe* 1.5 × 3 cm, falsely fasciculate, minutely tomentose at base, rough in surface,

creamy (4A3) to flesh (6B3), becoming darker to brownish orange (6C3) in age; surface obviously weakly brunnescent where handled; flesh white when young, in age suffused brown color, fibrous-fleshy, moist but not slippery or gelatinous, changing color to vinescent on bruising. *Major branches* 3–6, often terete or flattened, yellow ochre (5C7) to purplish gray (14D2); *Branches* 2–4 ranks, terete, ascending, concolorous with branches at base, purplish gray (14D2) to dull lilac (15C3) upward; flesh brownish near hymenium; surface vinescent around dirt specks and flesh slowly so when ripped; internodes diminishing gradually upward; axils broadly rounded (U shaped); *Apices* broadly rounded, double-dichotomous, concolorous with branches. Taste and odor not recorded.

Basidiospores [60/2/2] (9.4–)10.2–13.5(–14.3) × 4.7–6.7(–7.4) µm, $L_m = 11.38$ µm, $l_m = 5.62$ µm, $Q = (1.75\text{--})1.80\text{--}2.34(2.39)$, $Q_m = 2.03 \pm 0.16$, ellipsoid to cylindrical, conspicuously roughed in profile; wall up to 0.3 µm thick; hilar appendix prominent, truncate; ornamentation of large, flat warts and anastomosing ridges randomly placed. **Basidia** 40–55 × 8–12 µm, clavate, without clamps; sterigmata 4, stout, straight. **Subhymenium** rudimentary, hyphal. **Hymenium** unthickening. **Tramal hyphae of stipe** 4–12 µm wide, hyaline, parallel, thick walled to thick-walled, rarely obscuring cell lumen, without clamps, not agglutinated or adherent; ampulliform clamps up to 15 µm broad, thick-walled, with coarse ornamentation; gloeoplerous hyphae not observed. **Tramal hyphae of upper branches** 3–9 µm wide, hyaline, thick walled to thick-walled, without clamps, parallel, not agglutinated or adherent; ampulliform clamps up to 15 µm broad; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious in high-altitude *Quercus semecarpifolia* and *Picea asperata* forests. Basidiomata occurs in summer and autumn.

Distribution: known from southwestern China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 6 September 2021, P. Zhang 4299 (MHHNU 10799), P. Zhang 4308 (MHHNU 10808), P. Zhang 4310 (MHHNU 10810).

Commentary: *Ramaria sinospinulosa* bears resemblance to *R. spinulosa*. Both belong to a minor taxonomic group characterized by branches and apices in shades of brown, tan-brown, or violaceous tone, clampless hyphae, and wide basidiospores. Within this group, we find *R. spinulosa* (Pers.: Fr.) Qu é let, which has brown flesh and basidiospores measuring $L_m = 10.5$ µm, found in Europe and eastern North America), *R. fumosiavellanea* Marr & Stuntz, featuring off-white flesh and basidiospores measuring $L_m = 8.56$ µm, found in the Pacific northwest, and *R. spinulosa* var. *diminutiva* Petersen, displaying dark brown flesh and basidiospores measuring $L_m = 10.5$ µm, found in America. *Ramaria sinospinulosa* is distinguished by its small, falsely fasciculate stipe and longer basidiospores.

Furthermore, *R. sinospinulosa* demonstrates a closer phylogenetic relationship with *R. purpureivariabilis* and *R. purpurea*, found in Hubei and Yunnan provinces in China. They share common characteristics such as purplish brown basidiomata and rough basidiospores ornamentation. However, distinct differences exist with *R. sinospinulosa*: 1) Its basidiospores are slightly longer compared to the other two species; 2) It features falsely fasciculate stipes, whereas

the other two species possess either solitary or falsely fasciculate stipes; 3) The branch apices are broadly rounded, contrasting with the acute apices found in the other two species; 4) *R. sinospinulosa* thrives in high-altitude regions exceeding 3,500 meters, amidst mixed forests of *Quercus semecarpifolia* and *Picea asperata*, while the other two species prefer altitudes below 3,000 meters within mixed forests of conifers and broadleaf trees.

Ramaria ser. Zebrisporae P. Zhang & J. Zhong, **ser. nov.**

Mycobank: MB 852772

Etymology: “zebrispora” refers to basidiospores ornamentation that is streaked or striped.

Type species: *R. zebrispora* R.H. Petersen & M. Zang, Acta Mycol. Sin., Suppl. 1: 255, 1986.

Diagnosis: Basidiomata are milk white to yellow; context of stipe is flesh or gelatinous; basidia base and hyphae have clamps; basidiospores have conspicuous warts arranged in lines.

Commentary: Two species of this series are collected in China. Additionally, it includes species such as *R. thalioviorens* Franchi & M. Marchetti, *R. sandaracina* Marr & D.E. Stuntz, and its variety *R. sandaracina* var. *chondrobasis*. The basidiomata of these species are yellow to orange, with basidiospores ornamented with small warts arranged in linear patterns, and they possess relatively small basidiospores.

105. **Ramaria linearioides** R.H. Petersen & M. Zang, Acta Bot. Yunn. 11(4): 385, 1989. Fig. 39 a–b and Fig. 127

Description: **Basidiomata** 12 × 3–6 cm, solitary to gregarious. **Stipes** up to 1 × 3–4 cm, lobed to channeled, appearing fasciculate, tapering gradually downward; off-white at base, pale yellow to salmon upward; surface smooth or rugose; with abortive branches; not changing color to on bruising; context of stipe off-white when fresh, paler than hymenium, fleshy to fibrous, drying light in weight, easily penetrated, cartilaginous. **Major branches** 3–6 times, ascending, hardly terete. **Branches** in 3–5 ranks, major branches commonly polychotomous and lower branches mostly dichotomous; branches pale yellow to salmon; axils broadly rounded, U-shaped or V-shaped; internodes diminishing gradually at maturity, lower internodes up to 3 cm; branches 2–8 mm, seldom over 1 cm diam, terete, subparallel upward; context of main branches and upper branches fleshy to fibrous, off-white to pale orange. **Apices** molar-like when young, short-digitate at maturity, dichotomous, 2–10 mm, concolorous with branches or slightly changing color to brownish orange. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2] (8.1–)8.5–12.4(–13.2) × (3.3–)3.5–5.1(–6.0) µm, $L_m = 10.32$ µm, $l_m = 4.31$ µm, $Q = (2.00\text{--})2.15\text{--}2.68(2.87)$, $Q_m = 2.39 \pm 0.17$, ellipsoid, noticeably rough; ornamented with warts and short meandering ridges randomly placed, strongly cyanophilous warts; hilar conspicuous, slightly curved. **Basidia** 40–55 × 6–12 µm, clavate, with basal clamps; sterigmata 2–4, mostly 4, 3–6 µm long, slender and straight, somewhat scattered. **Hymenium** unthickening, 50–65 µm. **Subhymenium** extensive, hyphae, interwoven, 2–5 µm diam, adherent, with clamps. **Contextual hyphae:** Tramal hyphae of stipe 3–12 µm wide, hyaline, loosely parallel, ampulliform inflations up to 15 µm broad, with coarse ornamentation; tramal hyphae of branches central

hyphae slightly narrow, hyaline, thin-walled, strictly parallel, ampulliform inflations up to 15 μm broad; conspicuously

clamped; gloeoplerous hyphae not observed.



Fig. 127 Basidiospores of *R. linearioides* (MHHNU 10046). Scale bar: a = 10 μm .

Ecology: Solitary or gregarious on soil in mixed forests dominated by Fagaceae and Pinaceae, or in broad-leaved forests. Basidiomata appears in summer and autumn.

Distribution: Known from southwest China (Xizang, Yunnan, Sichuan).

Additional materials examined: CHINA, XIZANG AUTONOMOUS REGION: Linzhi, Sejila Mountain, Bayi District, Lulang Town, in a subalpine forest dominated by *Quercus*, altitude 3400 m, 26 August 2018, P. Zhang 3498 (MHHNU 9998), P. Zhang 3504 (MHHNU 10004), P. Zhang 3511 (MHHNU 10011), P. Zhang 3514 (MHHNU 10014), P. Zhang 3515 (MHHNU 10015), P. Zhang 3519 (MHHNU 10019), P. Zhang 3520 (MHHNU 10020); same city, Sejila Mountain, in a subalpine forest dominated by *Picea*, altitude 3300 m, 27 August 2018, P. Zhang 3542 (MHHNU 10042), P. Zhang 3543 (MHHNU 10043), P. Zhang 3544 (MHHNU 10044), P. Zhang 3546 (MHHNU 10046). YUNNAN PROVINCE: Shangri-La City, Xiaozhongdian Township, Tuanjie Village, Qianhu Mountain, in mixed forest, altitude 3450 m, 2 September 2022, P. Zhang 4871 (MHHNU 11371); same city, Deqin County, Baima Snow Mountain Nature Reserve, altitude 3750 m, 18 August 2018, P. Zhang 3463 (MHHNU 9963); same location, altitude 3700 m, 17 August 2018, P. Zhang 3442 (MHHNU 9942), P. Zhang 3443 (MHHNU 9943). SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 6 September 2021, P. Zhang 4304 (MHHNU 10804); same location, 5 September 2021, P. Zhang 4252 (MHHNU 10752), P. Zhang 4254 (MHHNU 10754); same city, Sewulong Village, within a *Picea* forest, altitude 3450 m, 5 September 2018, P. Zhang 3606 (MHHNU 10106); same location, altitude 3600 m, 3 September 2018, P. Zhang 3593 (MHHNU 10093); same location, Gongga Mountain, in the *Abies* forest, altitude 3500 m, 2 September 2021, P. Zhang 3582 (MHHNU 10082); same location, Waze Township, in *Picea* forest, altitude 3800 m, 1 September 2018, P. Zhang 3566 (MHHNU 10066), P. Zhang 3569 (MHHNU 10069), P. Zhang 3575 (MHHNU 10075), P. Zhang 3577 (MHHNU 10077), P. Zhang 3579 (MHHNU 10079); same location, Sewulong, in mixed forests dominated by *Picea asperata* and *Betula platyphylla*, altitude 3700 m, 28 August 2017, P. Zhang 2789 (MHHNU 9289); same location, 26 August 2017, P. Zhang 2774 (MHHNU 9274); same location, 23 August 2017, P. Zhang 2733 (MHHNU 9233), P. Zhang 2735 (MHHNU 9235); same location, 21 August 2017, P. Zhang 2591 (MHHNU 9091); same location, Moxigou, in broad-leaved forest with Fagaceae, altitude 3500 m, 1 August 2012, P. Zhang 1209 (MHHNU 7709).

Commentary: The main features of *R. linearioides* include:

1) basidiomata are medium sized to large, ranging in color pale yellow to salmon; 2) the flesh of the stipe is fleshy to slightly gelatinous, concolorous with branches; 3) does not change color upon bruising; 4) basidia base and hyphae lack clamps.

The species is nearly indistinguishable from *R. linearis*. Both share slender branches and a salmon-yellow color pattern, but they can be easily differentiated microscopically: *R. linearis* lacks clamps and has larger basidiospores. The stipe of *R. linearioides* is often rugose, and both the stipe and branches have fleshy to fibrous flesh, with dichotomous branching and medium sized basidiospores. *Ramaria linearioides* is most similar to *R. thalioviorens* Franchi & M. Marchetti, which also features salmon-colored basidiomata and clamps but has slightly smaller basidiospores ($8.0\text{--}10.0 \times 3.2\text{--}4.6 \mu\text{m}$, $L_m = 8.6 \mu\text{m}$, $l_m = 3.73 \mu\text{m}$, $Q = 2.00\text{--}2.70$, $Q_m = 2.3$; Franchi & Marchetti 2021) and is typically found in acid chestnut forests. This species has been observed in various forest types, suggesting it may not have a specific symbiotic relationship with particular trees.

106. *Ramaria zebrispora* R.H. Petersen & M. Zang, Acta Mycol. Sin., Suppl. 1: 255, 1986. Fig. 39 c–d and Fig. 128

Description: Basidiomata 13 cm high and 6.5 cm broad, subcylindrical to slender-obovate in outline. Stipes up to 5×2 cm, lobed to channeled, appearing fasciculate, tapering gradually downward, rounded below; off-white; involving almost no substrate when picked, slowly watery brown where bruised, vinaceous spots common; surface smooth; with abortive branches; context of stipe off-white when fresh, solid, firm, brittle, slippery or soapy to the touch. Major branches 2–5, up to 8 mm thick, erect, more or less terete; Branches in 4–6 ranks, major branches commonly polychotomous; cream or paler when young, cream to butter yellow by maturity; axils broadly rounded, mostly U-shaped; internodes length ratio diminishing gradually at maturity; context of main branches and upper branches fleshy to gelatinous, off-white, firm, not slippery; Apices slender, erect, minutely digitate to double-dichotomous, lemon yellow, remaining so at maturity. Odor negligible; taste weak, pleasant.

Basidiospores [55/2/2] $(7.0\text{--}7.5\text{--}10.0\text{--}(12.5) \times 3.5\text{--}4.7\text{--}(4.9) \mu\text{m}$, $L_m = 8.77 \mu\text{m}$, $l_m = 3.95 \mu\text{m}$, $Q = (1.67\text{--})1.88\text{--}2.54\text{--}(2.65)$, $Q_m = 2.20 \pm 0.19$, cylindrical to ellipsoid, very obscurely roughened in profile; ornamentation of raised, slender, cyanophilous striae oriented longitudinally on the

basidiospores wall. hilar appendix moderate; *Basidia* 40–55 × 7–9 µm, clavate, with basal clamps; sterigmata 4, long and straight. *Hymenium* thickening; *Subhymenium* rudimentary. *Contextual hyphae*: Tramal hyphae of stipe 3–8 µm wide, hyaline, thin-(usually) to thick-walled (wall up to 1 µm thick), occasionally clamped, tight packed, interwoven, extensively

adherent; inflated clamps up to 12 µm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, inflated clamps up to 14 µm broad, hyaline, unornamented; conspicuously clamped; gloeoplerous hyphae not observed.

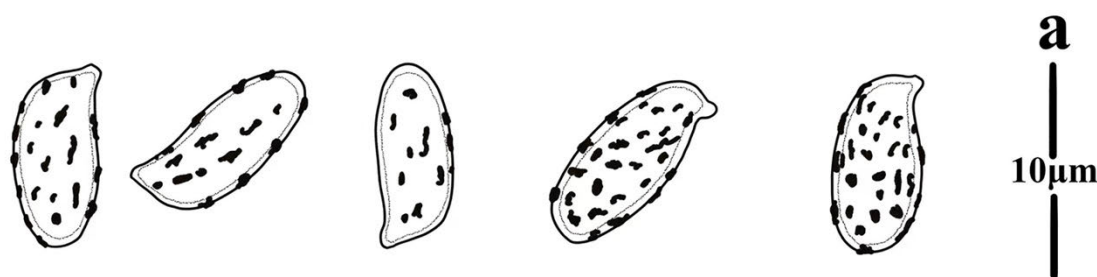


Fig. 128 Basidiospore of *R. zebrispora* (MHHNU 11272). Scale bar: a = 10 µm.

Basidiospores [55/2/2] (7.0–)7.5–10.0(–12.5) × 3.5–4.7(–4.9) µm, $L_m = 8.77$ µm, $l_m = 3.95$ µm, $Q = (1.67\text{--})1.88\text{--}2.54(–2.65)$, $Q_m = 2.20 \pm 0.19$, cylindrical to ellipsoid, very obscurely roughened in profile; ornamentation of raised, slender, cyanophilous striae oriented longitudinally on the basidiospores wall. hilar appendix moderate; *Basidia* 40–55 × 7–9 µm, clavate, with basal clamps; sterigmata 4, long and straight. *Hymenium* thickening; *Subhymenium* rudimentary. *Contextual hyphae*: Tramal hyphae of stipe 3–8 µm wide, hyaline, thin-(usually) to thick-walled (wall up to 1 µm thick), occasionally clamped, tight packed, interwoven, extensively adherent; inflated clamps up to 12 µm broad, with coarse ornamentation; tramal hyphae of branches central hyphae slightly narrow, inflated clamps up to 14 µm broad, hyaline, unornamented; conspicuously clamped; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in broad-leaved forests, basidiomata occurs in summer and autumn.

Distribution: Known from southwest China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Simao, 20 September 1983, Petersen45680 (isotype, HKAS 20045); Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved and coniferous mixed forest, altitude 2400 m, 23 August 2022, P. Zhang 4772 (MHHNU 11272); same city, Zixi Mountain, 2 August 2001, P. Zhang 121 (MHHNU 6621); Kunming City, Wuhua District, Qiongzhusi, altitude 2100 m, 14 October 2006, P. Zhang 587 (MHHNU 7087).

Commentary: The main features of *R. zebrispora* include: 1) the context of the stipe feels slippery or soapy to the touch; 2) basidia have clamps at their base; 3) the color changes upon bruising; 4) branches are cream-colored with yellow apices; 5) basidiospores are small and with raised, slender, cyanophilous striae oriented longitudinally.

Generally, species in ser. *Botrytes* and ser. *Hemirubellae* display basidiospores with striate ornamentation. In contrast, *R. zebrispora* exhibits basidiospores stripes arranged longitudinally, which differs from the oblique striping observed in the basidiospores of the ser. *Botrytes* and ser. *Hemirubellae*. While resembling the appearance of *R. flava-brunnescentiflava* (Atkinson) Corner, *R. zebrispora* can be differentiated by its smaller stipe and distinct basidiospores

ornamentation.

III. *Gomphus* within Gomphaceae consists of species with both ramarioid and cantharelloid-gomphoid basidioma.

***Gomphus* Pers., Tent. disp. meth. fung. (Lipsiae): 74 (1797)**

Type species: *Gomphus clavatus* (Pers.) Gray, Nat. Arr. Brit. Pl. (London) 1: 638 (1821)

Description: 1) Fruiting bodies are terrestrial, exhibiting cantharelloid-gomphoid or ramarioid forms. 2) Basidiospores are pigmented in basidiospores deposits, verrucose; 3) Clamps are present. 3) Most species exhibit purple hue.

In China, there are seven cantharelloid-gomphoid species and seven ramarioid species within *Gomphus*. A key to *Gomphus*, along with illustrations of these seven ramarioid species, is presented below.

Key to the species of *Gomphus* from China

1. Basidioma gomphoid 2
1. Basidioma ramarioid 8
2. Basidiomata becoming merismatoid at maturity, pileus fan-shaped 3
2. Basidiomata unipileate at maturity, occasionally merismatoid, pileus funnel-shaped to applanate, occasionally fan-shaped 5
3. Basidiomata vinaceous brown; context off-white; basidiospores 10–15 × 5–7.5 µm *Gom. clavatus*
3. Basidiomata bluish violet or yellowish brown; context violet or grayish violet. 4
4. Basidiomata bluish violet; violet context; basidiospores 12–14.5 × 6–8.5 µm *Gom. violaceus*
4. Basidiomata yellowish brown; grayish violet context; basidiospores 15–18 × 7–9 µm *Gom. orientalis*
5. Basidiospores $L_m < 13$ µm long 6
5. Basidiospores $L_m > 13$ µm long 7
6. Basidiomata brown or occasionally rosaceous; wrinkled, reticulate to almost poroid, pale violet to milky-coffee colored; basidiospores 7.5–10 × 3.5–5 µm *Gom. brunneus*
6. Basidiomata gray-blue to blue or blue-purple; hymenium wrinkled, gray-blue to blue-purple or gray; basidiospores 9–11 × 6–7 µm *Gom. matijun*

7. Basidiomata sordid yellow to orangish brown; hymenium wrinkled, violet; basidiospores $13\text{--}15 \times 5.5\text{--}6 \mu\text{m}$
 *Gom. crassipes*
7. Basidiomata dull “benzo brown” to “deep quaker drab”, bruising darker, some pale surface over-center; delicately wrinkled, purple-gray; basidiospores $14\text{--}17 \times 5\text{--}7 \mu\text{m}$
 *Gom. ludovicianus*
8. Basidioma off-white to pale yellow, without purple hue 9
8. Basidioma with purple hue 10
9. creamy-white to pale yellow, becoming purple brown with age, average basidiospores size $9.33 \times 5.65 \mu\text{m}$
 *Gom. luteolus*
9. Basidioma creamy-white to pale yellow, becoming purple brown with age, with broader basidiospores ($9.33 \times 6.25 \mu\text{m}$)
 *Gom. latisoriluteolus*

10. Basidioma bright purple 11
10. Basidioma with pale purple, dark purple, or purple color only apparent at apices 12
11. Stout stipe with long branches *Gom. discopurpurea*
11. Stout stipe with short branches *Gom. asiaticaviolaceus*
12. Basidiospores spindle-shaped, l_m (width) $< 5 \mu\text{m}$
 *Gom. fusisporus*
12. Basidiospores sub-fusiform to long ellipsoid, l_m (width) $> 5 \mu\text{m}$ 13
13. Basidioma cream to olive-green to brownish to brownish at maturity *Gom. asiaticus*
13. Basidioma cinnamon brown to grayish violet
 *Gom. bicolor*



Fig. 129 Fresh basidiomata of representative species in *Gomphus*. **a–b** *Gom. asiaticus* (a, MHHNU 11263; b, MHHNU 11318); **c–d** *Gom. asiaticaviolaceus* (Holotype, c, MHHNU 10803; d, MHHNU 7706); **e–f** *Gom. bicolor* (Holotype, e, MHHNU 11641; f, MHHNU 30740); **g–i** *Gom. discopurpurea* (Holotype, g, HKAS 105897; h, MHHNU 31287; i, MHHNU 11638); **j–k** *Gom. fusisporus* (Holotype, j, MHHNU 11246; k, MHHNU 11316); **l–m** *Gom. latisoriluteola* (Holotype, l, HKAS 133166; m, MHHNU 9881); **n–o** *Gom. luteolus* (TYPE n, MHHNU 11228 and o, MHHNU 32957). Bars = 2 cm.

107. *Gomphus asiaticus* (R.H. Petersen & M. Zang) P. Zhang & J. Zhong, **comb. nov.**, Sydowia 40: 199, 1988. Fig. 129 a–b and Fig. 130

≡ *Ramaria violaceibrunnea* var. *asiatica* R.H. Petersen & M. Zang, Acta bot. Yunn. 8(3): 291, 1986.

≡ *Ramaria asiatica* (R.H. Petersen & M. Zang) R.H. Petersen, Sydowia 40: 199 (1987)

Description: *Basidiomata* 5.5–8.5 cm high and 2.5–5 cm broad, small to medium sized. *Stipe* 1 × 3 cm, single to falsely fasciculate; substrate below off-white, flaxen to dull lilac above; not changing color on bruising; fine white tomentum

increases, otherwise smooth; with abortive branches; context of stipe off-white when fresh, fleshy, solid, hard when dry. *Major branches* several, terete; *Branches* in 3–5 ranks, abruptly arising from major branches, terete, crowded when young, long at maturity; cinnamon brown to grayish violet; axils rounded, U shaped; internodes short. Context of main branches and upper branches fleshy, off-white. *Apices* cusped, dichotomous, olive yellow when young, concolorous with branches or grayish violet with slightly violet to brown hue by maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.



Fig. 130 Basidiospore features of *Gom. asiaticus* (MHHNU 11263). Scale bar: a = 10 µm.

Basidiospores [55/3/3](9.0)10.7–13.9(–14.0) × 4.5–6.5(–6.6) µm, $L_m = 12.03$ µm, $l_m = 5.74$ µm, $Q = (1.73)–1.86–2.60(–2.92)$, $Q_m = 2.19 \pm 0.15$, sub-fusiform to long ellipsoid; conspicuously roughened in profile, wall up to 0.2 µm thick; hilar appendix prominent, broad; ornamentation of complex low warts and short ridges, often in transverse orientation. *Basidia* 45–65 × 8–11 µm, clavate, attenuate below, clamped; sterigmata 4, long, straight. *Hymenium* thickening, 50–70 µm; *Subhymenium* extensive, hyphae 2–3.5 µm diam, thin-walled, clamped, hyaline, very tightly packed, interwoven, free; *Contextual hyphae*: Tramal hyphae of stipe 3–11 µm wide, hyaline, thick-walled (wall up to 2 µm thick), clamped, free interwoven; ampulliform inflations up to 12 µm broad, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed. tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, clamped, locally adherent, parallel, tightly packed; ampulliform inflations occasional, thin walled, unornamented; gloeoplerous hyphae as short, cudgel-shaped.

Ecology: Solitary or gregarious on soil in coniferous and broad-leaved mixed forests. Basidiomata occurs in summer and autumn.

Distribution: In southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Simao, 20 September 1983, Petersen45674 (isotype, HKAS 10424); Chuxiong, Mouding County, Huafo Mountain, in a pine forest, altitude 2400 m, 23 August 2023, P. Zhang 5026 (MHHNU 11526), P. Zhang 5027 (MHHNU 11527), P. Zhang 5029 (MHHNU 11529), P. Zhang 5031 (MHHNU 11531), P. Zhang 5032 (MHHNU 11532); same location, in the mixed forest, altitude 2000 m, 23 August 2022, P. Zhang 4762 (MHHNU 11262), P. Zhang 4763 (MHHNU 11263), P. Zhang 4771 (MHHNU 11271); same location, altitude 2350 m, 21 August 2022, P. Zhang 4738 (MHHNU 11238); same City, Zixi Mountain, in a forest with *Lithocarpus*

and *Pinus yunnanensis*, altitude 2400 m, 2 August 2001, P. Zhang 124 (MHHNU 6624); Dali, Binchuan County, Jizu Mountain, with broad-leaved, coniferous or mixed forests, altitude 2300 m, 29 August 2022, P. Zhang 4818 (MHHNU 11318); same city, Xianyangfeng, in a mixed forest, altitude 2800 m, 12 August 2018, P. Zhang 3372 (MHHNU 9872), P. Zhang 3376 (MHHNU 9876), P. Zhang 3377 (MHHNU 9877), P. Zhang 3384 (MHHNU 9884), P. Zhang 3385 (MHHNU 9885); Wenshan, Malipo County, Xinhe Village, in broad-leaved forest with Fagaceae, altitude 1200 m, 4 August 2018, P. Zhang 3324 (MHHNU 9824), P. Zhang 3334 (MHHNU 9834), P. Zhang 3335 (MHHNU 9835), P. Zhang 3336 (MHHNU 9836); same locaiton, Haiziping, altitude 1500 m, 3 August 2018, P. Zhang 3308 (MHHNU 9808), P. Zhang 3309 (MHHNU 9809), P. Zhang 3310 (MHHNU 9810); Pu'er, Lancang County, Menglang Town, brought from mushroom market, 30 July 2017, P. Zhang 2625 (MHHNU 9125), P. Zhang 2626 (MHHNU 9126), P. Zhang 2632 (MHHNU 9132).

Commentary: *Gomphus asiaticus* is similar to *Gom. fusisporus*, with both species distributed in southwestern China. They share yellow-brown to purple-brown basidiomata, olive-yellow apices in early stages, spindle-shaped basidiospores of similar size, and the characteristic presence of clamps. However, *Gom. asiaticus* tends to have a cinnamon hue in its basidiomata, and young specimens may sometimes exhibit a creamy color.

In northern Yunnan, *Gom. asiaticus* was collected at 3200 meters above sea level in a mature forest of *Picea*, *Apice*, broad-leaved trees, and undergrowth of *Sinarundinaria*. This forest appears to be especially rich in *Ramaria* species and should be investigated further. Unlike other taxa, this species was not for sale at the local market, although the type specimen (from Simao) was purchased, attesting to the edibility of its basidiomata.

108. *Gomphus asiaticaviolaceus* P. Zhang & J. Zhong, **sp. nov.** Fig. 129 c–d and Fig. 131

MycoBank: MB 853008

Etymology: The specific epithet "*asiaticaviolaceus*" indicates that the species is native to Asia and has a violet color similar to *R. violacea*.

Diagnosis: Basidiomata are bright purple to purple-brown in color; stipe is single and stout; basidiospores have

conspicuously warts that are strongly cyanophilous; basidia base and hyphae possess clamps; basidia are long.

Type: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, in *Quercus semecarpifolia* and *Picea asperata* forest, altitude 3900 m, 6 September 2021, P. Zhang 4303 (Holotype, MHHNU 10803, GenBank Acc. No.: ITS = PP467133, nrLSU = PP493462, *tef1-a* = PP480351).

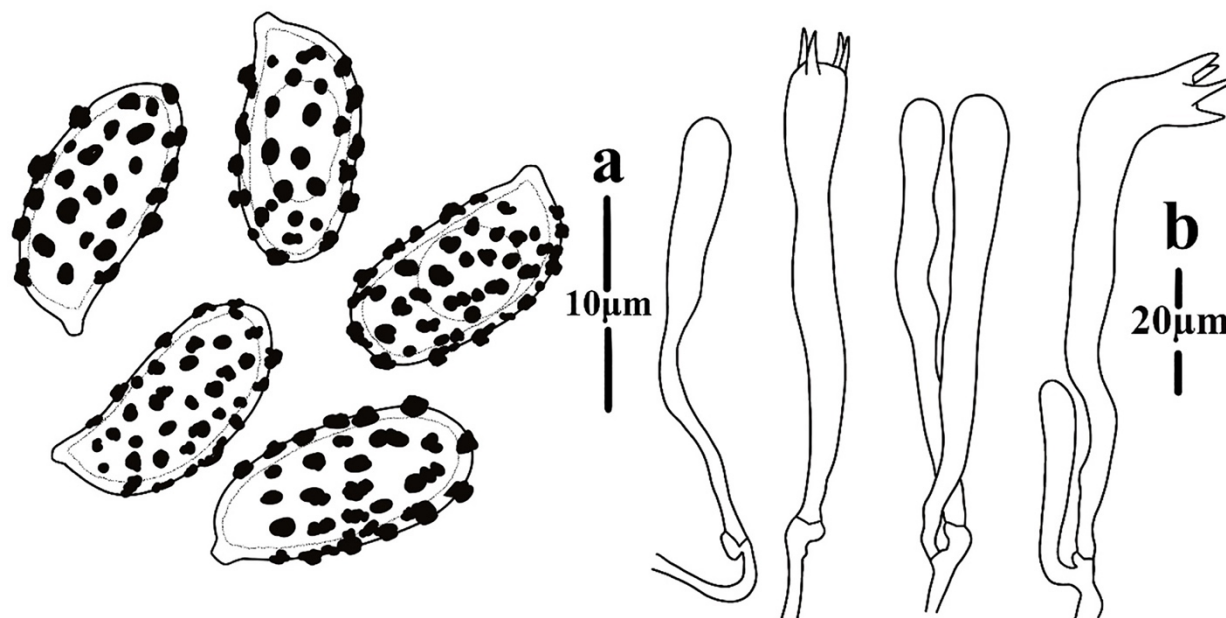


Fig. 131 Microscopic features of *Gom. asiaticaviolaceus* (MHHNU 10803). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 15 cm high and 10 cm broad, medium sized. *Stipe* 1.5 × 5 cm, single to falsely fasciculate, with white pruinose; surface lavender blue (18B3) to purplish gray (14D2); not changing color when handle; without abortive branches; context of stipe off-white (1A1) when fresh, fleshy to fibrous, hard when dry. *Major branches* several, terete or flattened; *Branches* in 2–4 ranks, sparse, main branches and upper branches mostly polychotomous; light violet (17A5) to reddish lilac (14B4); axils mostly broadly rounded, U shaped; internodes all short; context of main branches and upper branches fleshy to fibrous, off-white (1A1). *Apices* cusped, dichotomous, concolorous with branches, grayish violet (17D5), with slightly brown (6E8) when injury. Odor weakly fragrant, aromatic; taste bitter.

Basidiospores [45/2/2] (10.7–)11.1–13.9(–14.0) × (4.5–)4.8–6.5(–6.6) µm, $L_m = 12.18$ µm, $l_m = 5.74$ µm, $Q = (1.73–)1.86–2.38(–2.92)$, $Q_m = 2.16 \pm 0.15$, ellipsoid; conspicuously roughened in profile, thick-walled; hilar appendix prominent; ornamentation of complex low warts, often in transverse orientation. *Basidia* 65–85 × 7–11 µm, clavate, clamped; sterigmata 1–4, mostly 4, stout, straight, 7–10 µm long. *Hymenium* thickening, 70–90 µm; *Subhymenium* extensive, hyphae 2–3.5 µm diam, thin-walled, clamped, hyaline, very tightly packed, interwoven, free; *Contextual hyphae*: Tramal hyphae of stipe 3–11 µm wide, hyaline, clamped, free interwoven; ampulliform inflations up to 12 µm broad, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed. tramal hyphae of branches central hyphae slightly narrow, hyaline, thin walled, clamped, locally

adherent, parallel, tightly packed; ampulliform inflations occasional, thin walled, unornamented; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in mixed forests. *Basidiomata* occurs in summer and autumn.

Distribution: In southwestern China (Sichuan).

Additional materials examined: CHINA, SICHUAN PROVINCE: Ganzi, Kangding City, Gongga Mountain, Mouxigou, in broad-leaved forest with Fagaceae, altitude 3500 meters, 1 August 2012, P. Zhang 1206 (MHHNU 7706); same city, Seda County, altitude 3775 m, 6 August 2005, Zai W. Ge 777 (HKAS 49272).

Commentary: The violet, clamped species of *Ramaria* and ramarioid *Gomphus*, characterized by stout stipes, include north American *R. purpurissima* var. *purpurissima*, north African *R. cedretorum*, and European *Gom. violacea*. This bright violet color is a crucial identifying feature of these ramarioid *Gomphus*, particularly in high-altitude regions of southwest China.

109. *Gomphus bicolor* P. Zhang & Gui W. Li, **sp. nov.** Fig. 129 e–f and Fig. 132

MycoBank: MB 853030

Etymology: "*bicolor*" refers to the upper stipe and lower branches of the species being purple-brown in color, while the branches themselves are brown.

Diagnosis: Differs from species of ser. *Fennicae* in having purple-colored upper stipes and lower branches, while the apices range from mustard yellow to purple-red.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Nanhua County, Dazhongshan Forestry Farm, in mixed broadleaf-coniferous forest dominated by Fagaceae and Pinaceae,

altitude 2310 m, 10 August 2017, Jian W. Liu 860 (Holotype, MHHNU 11641, GenBank Acc. No.: ITS = PP467135, nrLSU = PP493463, *tef1-α* = PP480353).

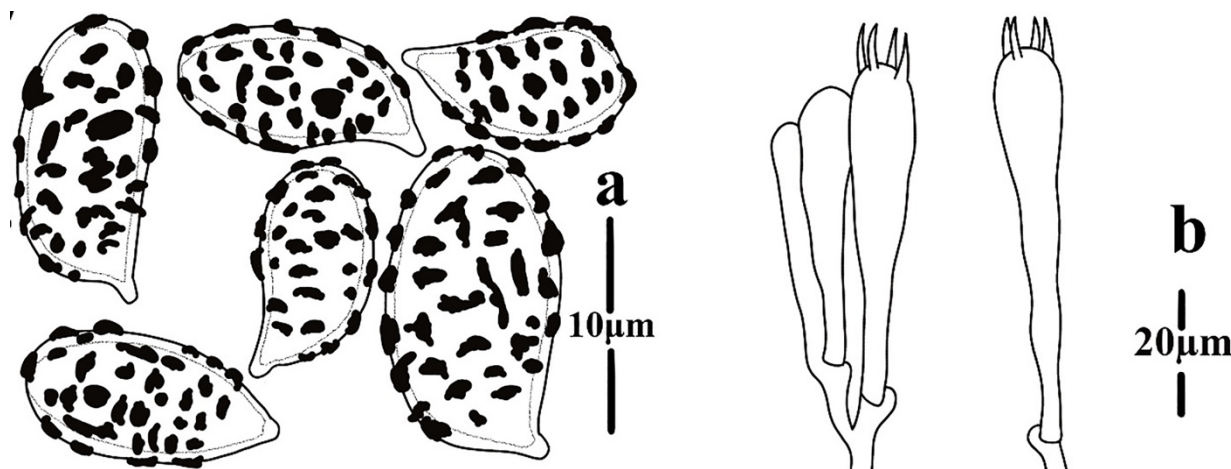


Fig. 132 Microscopic features of *Gom. bicolor* (MHHNU 11641). a basidiospores; b basidia and Hymenium. Scale bars: a = 10 μm, b = 20 μm.

Description: *Basidiomata* 3–7 cm high and 2–5 cm broad, medium sized. *Stipe* 0.2–1 × 0.2–2 cm, single to falsely fasciculate, pruinose at base; substrate below off-white (1A1), purplish gray (14D2) to dull lilac (15C3) above; not changing color on bruising; surface smooth; with abortive branches; context of stipe off-white (1A1) when fresh, fleshy to fibrous, hard when dry. *Major branches* several, terete; *Branches* in 2–5 ranks, sparse, main branches and upper branches mostly dichotomous; cinnamon brown (6D6) to grayish violet (17D5); axils mostly broadly rounded, U shaped; internodes diminishing gradually at maturity; Context of main branches and upper branches fleshy to fibrous, off-white (1A1). *Apices* cusped, dichotomous, olive yellow (3D7) when young, concolorous with branches or grayish violet (17D5) with slightly violet-brown (11F8) by maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2](10.0–)10.5–12.5(–13.2) × (4.4–)4.6–6.0(–6.2) μm, $L_m = 11.57$ μm, $l_m = 5.23$ μm, $Q = (1.74)–1.98–2.54(–2.73)$, $Q_m = 2.22 \pm 0.19$, long ellipsoid; conspicuously roughened in profile, wall up to 0.2 μm thick; hilar appendix prominent, broad; ornamentation of complex low warts and short ridges, often in transverse orientation. *Basidia* 50–75 × 9–12 μm, clavate, clamped; sterigmata 4, long, straight. *Hymenium* thickening, 50–70 μm; *Subhymenium* extensive, hyphae 2–3.5 μm diam, thin-walled, clamped, hyaline, very tightly packed, interwoven, free; *Contextual hyphae*: Tramal hyphae of stipe 3–11 μm wide, hyaline, thick-walled (wall up to 2 μm thick), clamped, free interwoven; ampulliform inflations up to 12 μm broad, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed. tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, clamped, locally adherent, parallel, tightly packed; ampulliform inflations occasional, thin walled, unornamented; gloeoplerous hyphae as short, cudgel-shaped.

Ecology: Solitary or gregarious on soil in the coniferous and broad-leaved mixed forest. *Basidiomata* occurs in summer and autumn.

Distribution: In southwestern and central China (Yunnan, Hunan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Wenshan, Malipo County, Donggan Town, Malibao Village, in broad-leaved forest with Fagaceae, altitude 1700 m, 6 August 2018, P. Zhang 3353 (MHHNU 9853); Chuxiong, Zixi Mountain, in a forest with *Lithocarpus* and *Pinus yunnanensis*, altitude 2400 m, 2 August 2001, P. Zhang 118 (MHHNU 6618). HUNAN PROVINCE: Changde City, Shimen County, Hupingshan Town, Hupingshan National Nature Reserve, in a broad-leaved forest, altitude 1000 m, 3 October 2010, Zuo H. Chen 30754 (MHHNU 30754); same location, Guan Mountain, 2 September 2010, P. Zhang 871 (MHHNU 7371).

Commentary: This species was regarded as *R. mairei* (Zhang 2010), based on only two specimens where the upper stipe and lower branches appear purple, while the branches are brown. *Ramaria mairei* is frequently mentioned in domestic literature, and all branched fungi with a purple hue are often classified as *R. mairei*. However, according to Donk's (1933) original description, *R. mairei* is characterized by a stout stipe and some toxicity. Upon observing more specimens, it was noted that the color of *R. mairei* varies from brown to purple-brown, and the apices of some specimens distinctly show an olive-green.

In fact, *Gom. bicolor* shares more characteristics with *R. himalayensis* R.H. Petersen from southeast Asia. *Ramaria himalayensis* was initially collected and reported by Sharda in Bhutan. Petersen described this species as having slender and gracile stipes, with the upper stipe and/or lower branches appearing violet, and the branches being grayish yellow to dull yellow, with apices concolorous with the upper branches. Compared to *Gom. bicolor*, *R. himalayensis* is more slender and larger in size (18 × 7 cm), with slightly larger basidiospores (11.5–14 × 5–6.5 μm, $L_m = 12.47$ × 5.72 μm, $Q = 1.94–2.5$; $Q_m = 2.18$; Petersen 1987).

110. *Gomphus discopurpurea* P. Zhang & J. Zhong, **sp. nov.** Fig. 129 g–i and Fig. 133

Mycobank: MB 853011

Etymology: “*discopurpurea*” = *discolor* + *purpurea*, indicating that the species is initially purple but easily turns

brown or reddish-brown.

Diagnosis: Basidiomata are purple to red purple; does not change color when injured; basidiospores have conspicuous warts that are strongly cyanophilous; basidia base and hyphae have clamps.

Type: CHINA, YUNNAN PROVINCE: Wenshan, Qiubei County, Xiangqi Village, in a mixed forest by *Keteleeria* and *Pinus*, altitude 1538 m, 12 July 2017, Zai W. Ge 3983 (Holotype, HKAS 105897, GenBank Acc. No.: ITS = PP467130, nrLSU = PP49346).

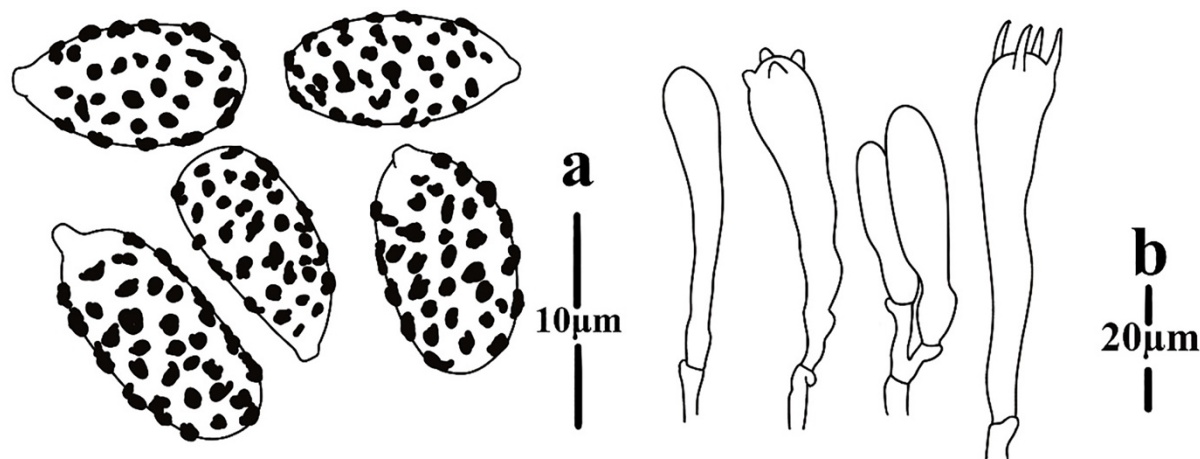


Fig. 133 Microscopic features of *Gom. discopurpurea* (HKAS 105897). a basidiospores; b basidia. Scale bars: a = 10 μm, b = 20 μm.

Description: *Basidiomata* 6–10 cm high and 14.5–6 cm broad, medium sized. *Stipe* 2–2.5 × 1–2 cm, single to falsely fasciculate, with white pruinose; surface lavender blue (18B3) to purplish gray (14D2); not changing color when handle; without abortive branches; context of stipe off-white (1A1) when fresh, fleshy to fibrous, hard when dry. *Major branches* several, terete or flattened; *Branches* in 2–4 ranks, sparse, main branches and upper branches mostly polychotomous; light violet (17A5) to reddish lilac (14B4); axils mostly broadly rounded, U shaped; internodes all short; context of main branches and upper branches fleshy to fibrous, off-white (1A1). *Apices* cusped, dichotomous, concolorous with branches, grayish violet (17D5), with slightly brown (6E8) when injury. Odor weakly fragrant, aromatic; taste bitter.

Basidiospores [60/2/2] (9.3–)9.8–12.5(–13.6) × (4.0–)4.7–6.1(–6.8) μm, $L_m = 11.05$ μm, $l_m = 4.73$ μm, $Q = (1.71)–1.89–2.53(–2.75)$, $Q_m = 2.19 \pm 0.22$, ellipsoid; conspicuously roughened in profile, thick-wall; hilar appendix prominent; ornamentation of complex low warts, often in transverse orientation. *Basidia* 40–65 × 8–12 μm, clavate, clamped; sterigmata 1–4, mostly 4, stout, straight, 4–7 μm long. *Hymenium* thickening, 50–70 μm; *Subhymenium* extensive, hyphae 2–3.5 μm diam, thin-walled, clamped, hyaline, very tightly packed, interwoven, free; *Contextual hyphae*: Trametal hyphae of stipe 3–9 μm wide, hyaline, clamped, free interwoven; ampulliform inflations up to 10 μm broad, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed. trametal hyphae of branches central hyphae slightly narrow, hyaline, thin walled, clamped, locally adherent, parallel, tightly packed; ampulliform inflations occasional, thin walled, unornamented; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in mixed forests. Basidiomata occurs in summer and autumn.

Distribution: In southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Chuxiong, Lufeng County, in the mixed forest, 24

September 2022, P. Zhang 4881 (MHHNU 11381); same city, Shuangbai County, 22 August 2018, Zuo H. Chen 31287 (MHHNU 31287); Kunming City, Panlong District, Heilongtan Park, altitude 2140 m, 13 August 2016, Jian W. Liu 536 (MHHNU 11638).

Commentary: The distinctive purple color of *Gom. discopurpurea* places it within a unique group among *Ramaria* species, showing a close affinity to the *Gom. ludovicianus* Petersen in the order Gomphales. Although *Gom. ludovicianus* has an agaric-shaped fruiting body, its basidiomata shares a similar purple coloration and both species exhibit clamps. Within *Ramaria*, species with purple coloration and clamps appear to form a distinct subgroup, showing close molecular phylogenetic relationships with purple-colored mushrooms in Gomphales. These species are easily identifiable due to their intense purple color, and their microscopic structures are quite similar. Based on the currently collected basidiomata from the field, the diversity within this group seems limited, and species can be distinguished by considering fruiting body color, morphology, and basidiospores size.

111. *Gomphus fusisporus* P. Zhang & J. Zhong, **sp. nov.** Fig. 129 j–k and Fig. 134

Mycobank: MB 853029

Etymology: *fusisporus* = “fusi” (spindle-shaped) + “spora” (spores), indicating that the species has spindle-shaped basidiospores.

Diagnosis: Basidiomata are purple to purplish-brown, and the color persists even in maturity; the stipe is twisted, with flesh that is white when young, turning purple as it matures; apices are olive-yellow when young, becoming concolorous with branches when mature; basidia base and hyphae have clamps; prefers to grow under pine trees.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved forest, altitude 2350 m, 21 August 2022, P. Zhang 4746 (Holotype, MHHNU

11246, GenBank Acc. No.: ITS = PP467139, nrLSU = PP493467, *tef1-α* = PP480357).

Description: *Basidiomata* 7 cm high and 5 cm broad, small to medium sized. *Stipe* 4 × 2 cm, aggregated, gnarled, irregular; substrate below off-white (1A1), pale violet (17A3) to dull lilac (15C3) above; not changing color on bruising; fine white tomentum increases, otherwise smooth; with abortive branches; context of stipe off-white (1A1) when fresh, fleshy, solid, hard when dry. *Major branches* several, arising together, terete; *Branches* in 3–5 ranks, abruptly arising from

major branches, terete, crowded when young, long at maturity; dull lilac (15C3) to grayish violet (17D5); axils rounded, U shaped; internodes diminishing gradually at maturity. Context of main branches and upper branches fleshy, off-white (1A1). *Apices* cusped, dichotomous, olive yellow (3D7) when young, concolorous with branches or grayish violet (17D5) with slightly violet to brown hue (11F8) by maturity. Odor weakly fragrant, aromatic; taste negligible to faintly astringent.

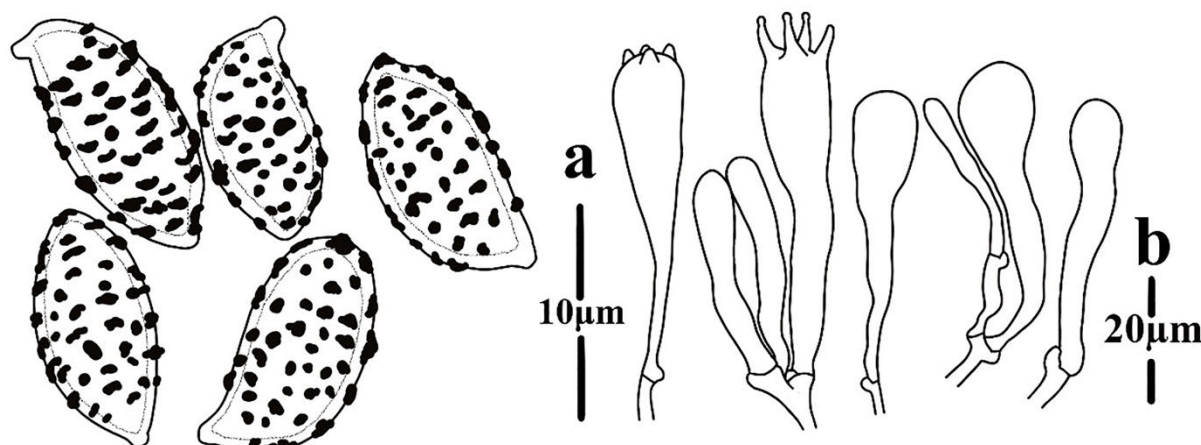


Fig. 134 Microscopic features of *Gom. fusisporus* (MHHNU 11246). a basidiospores; b basidia. Scale bars: a–b = 2 cm, c = 10 μm, d = 20 μm.

Basidiospores [90/3/3](8.7–)9.8–13.6(–15.2) × (4.2–)4.4–5.8(–6.1) μm, $L_m = 11.57$ μm, $l_m = 4.81$ μm, $Q = (1.85–)1.97–2.74(–3.10)$, $Q_m = 2.40 \pm 0.18$, sub-fusiform to long ellipsoid; conspicuously roughened in profile, wall up to 0.2 μm thick; hilar appendix prominent, broad; ornamentation of complex low warts and short ridges, often in transverse orientation. **Basidia** 45–65 × 8–13 μm, clavate, attenuate below, clamped; sterigmata 4, long, straight. **Hymenium** thickening, 50–70 μm; **Subhymenium** extensive, hyphae 2–3.5 μm diam, thin-walled, clamped, hyaline, very tightly packed, interwoven, free; **Contextual hyphae**: Tramal hyphae of stipe 3–11 μm wide, hyaline, thick-walled (wall up to 2 μm thick), clamped, free interwoven; ampulliform inflations up to 12 μm broad, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed. tramal hyphae of branches central hyphae slightly narrow, hyaline, thin-walled, clamped, locally adherent, parallel, tightly packed; ampulliform inflations occasional, thin walled, unornamented; gloeoplerous hyphae as short, cudgel-shaped.

Ecology: Solitary or gregarious on soil in coniferous and broad-leaved forests. *Basidiomata* occurs in summer and autumn.

Distribution: In southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Dali City, Binchuan County, Jizu Mountain, with broad-leaved, coniferous or mixed forests, altitude 2300 m, 29 August 2022, P. Zhang 4816 (MHHNU 11316); Chuxiong, Zixi Mountain, in mixed forests dominated by Fagaceae and Pinaceae, altitude 2200 m, 24 August 2022, P. Zhang 4785 (MHHNU 11285); same city, Mouding County, Huafo Mountain, in a broad-leaved forest, altitude 2350 m, 21 August 2022, P. Zhang 4747 (MHHNU 11247).

Commentary: *Gomphus fusisporus* shares similar

characteristics with *R. violaceibrunnea*, as described by Petersen (1987). The latter is synonymous with *R. versatilis* var. *violaceibrunnea* (Marr & D.E. Stuntz) R. H. Petersen & Zang and *R. fennica* var. *violaceibrunnea* Marr & D.E. Stuntz. Marr described *R. violaceibrunnea* as exhibiting a light purple to dull purple color when young, changing to grayish red in maturity, with basidiospores measuring 10.7 × 4.7 μm (Marr & Stuntz 1973). Petersen described its apices as olive-brown to yellow-brown when young, turning olive-brown upon maturation, with basidiospores measuring 9–13 × 4.3–5.4 μm (Petersen 1987). The basidiospores size of *Gom. fusisporus* collected in southwestern China is slightly larger than that described for *R. violaceibrunnea* by Marr & Petersen, however, the basidiospores shapes are similar, displaying a slightly curved, near-fusiform shape, though not every basidiospores exhibits this morphology. In addition to color and basidiospores size differences, the stipe of *Gom. fusisporus* from China is twisted and irregular, while Marr & Petersen described the stipe of *R. violaceibrunnea* as solitary to clustered and not irregular in shape.

112. *Gomphus latispoluteolus* P. Zhang & Gang Wu, **sp. nov.** Fig. 129 l–m and Fig. 135

Mycobank: MB 853032

Etymology: *latispoluteolus* = *latispore* + *luteolus*, indicating that the species has broad basidiospores and is cream to yellow in color.

Diagnosis: *Basidiomata* are cream when young, becoming dull yellow upon maturity; stipe falsely fasciculate, smooth, does not change color when injured; apices are cusped, polychotomous, and turn milk white when mature; basidia base and hyphae feature clamps; basidiospores are small, short and broad, with prominent warts.

Type: CHINA, YUNNAN PROVINCE: Wenshan, Malipo County, Donggan Township, Wengxiulin Village, in broad-leaved forest, altitude 1800 m, 27 July 2017, G. Wu 2212

(Holotype, HKAS 133166, GenBank Acc. No.: ITS = PP467128, nrLSU = PP493458).

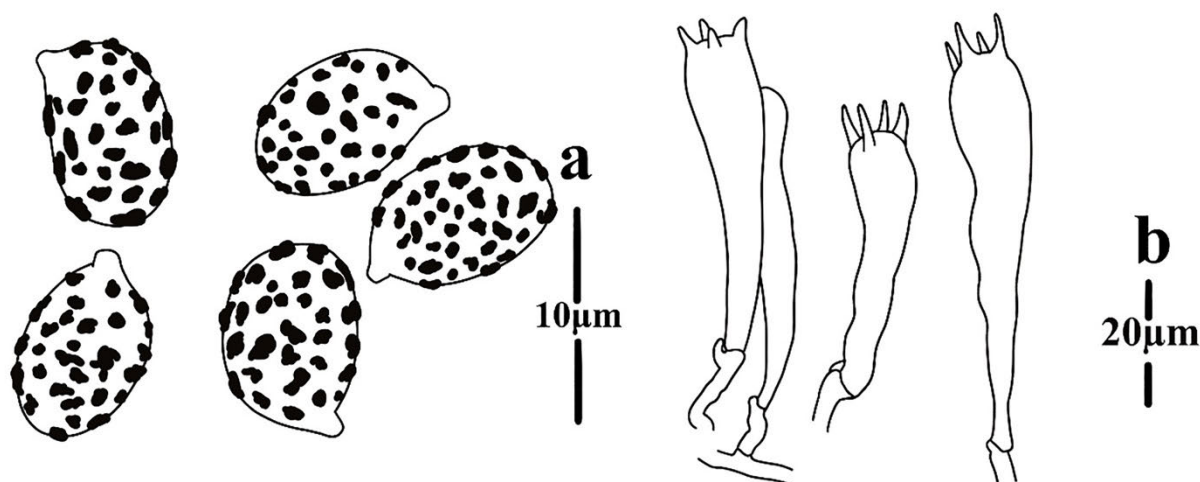


Fig. 135 Microscopic features of *Gom. latispoluteolus* (HKAS 133166). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Description: *Basidiomata* 12 cm high and 10 cm broad, medium sized. *Stipe* 2 × 0.5 cm, falsely fasciculate, pruinose at base; substrate below off-white (1A1), purplish pale yellow (2A3) to grayish yellow (2B5) above; appearing hydrophanous when handle, not changing color; surface smooth; without abortive branches; context of stipe off-white (1A1) when fresh, fleshy to fibrous, hard when dry. *Major branches* several, terete; *Branches* in 2–5 ranks, sparse, main branches and upper branches mostly polychotomous; cream (4A3) to dull yellow (3B3); axils mostly broadly rounded, U shaped; internodes all short; context of main branches and upper branches fleshy to fibrous, off-white (1A1). *Apices* short and crowded, stout and cusped, polychotomous, concolorous with branches when young, milk white (1A2) by maturity. Odor weakly fragrant, aromatic; taste bitter.

Basidiospores [30/1/1] (8.0–)8.1–10.4(–10.5) × (4.7–)5.5–7.2(–7.5) µm, $L_m = 9.33$ µm, $l_m = 6.25$ µm, $Q = (1.27)–1.30–1.74(–1.99)$, $Q_m = 1.51 \pm 0.16$, ellipsoid; conspicuously roughened in profile, thick-wall; hilar appendix prominent; ornamentation of complex low warts, often in transverse orientation. *Basidia* 40–65 × 9–13 µm, clavate, clamped; sterigmata 1–4, mostly 4, stout, straight. *Hymenium* unthickening, 50–70 µm; *Subhymenium* extensive, hyphae 2–3.5 µm diam, thin-walled, clamped, hyaline, very tightly packed, interwoven, free; *Contextual hyphae*: Tramal hyphae of stipe 3–8 µm wide, hyaline, clamped, free interwoven; ampulliform inflations up to 10 µm broad, not unusually thick-walled, unornamented; gloeoplerous hyphae not observed. tramal hyphae of branches central hyphae slightly narrow, hyaline, thin walled, clamped, locally adherent, parallel, tightly packed; ampulliform inflations occasional, thin walled, unornamented; gloeoplerous hyphae not observed.

Ecology: Solitary or gregarious on soil in a broad-leaved forest. *Basidiomata* occurs in summer and autumn.

Distribution: In southwestern China (Yunnan).

Additional material examined: CHINA, YUNNAN PROVINCE: Dali, Dali City, Xieyangfeng, in a mixed forest, altitude 2800 m, 12 August 2018, P. Zhang 3381 (MHHNU 9881).

Commentary: The distinctive coloration of *Gom.*

latispoluteolus sets it apart from its phylogenetically related species in *Gomphus*. Unlike many others that exhibit varying degrees of purple, *Gom. latispoluteolus* entirely lacks any purple tones, instead leaning towards a dull yellow hue with white branch apices. Its prominently warted, nearly ellipsoidal small-sized basidiospores also aid in its straightforward identification. This species is closely related to *R. cartilaginea* Marr & D.E. Stuntz (1973) from the United States, sharing similar warted small-sized basidiospores (spore size in the latter is 7.5–11 × 4–6 µm, $L_m = 8.8$ µm, $l_m = 4.5$ µm, $Q_m = 1.96$). However, *R. cartilaginea* distinguishes itself with a stout stipe and a cauliflower-like in appearance.

113. *Gomphus luteolus* P. Zhang & J. Zhong, **sp. nov.** Fig. 129 n–o and Fig. 136

Mycobank: MB 853031

Etymology: “*luteolus*” means the species is cream to yellow colored.

Diagnosis: Young *basidiomata* are cream-colored, turning purplish to brown as they mature; no color change upon bruising; basidiospores are wide and short, featuring prominent warts; basidia base and hyphae exhibit clamps.

Type: CHINA, YUNNAN PROVINCE: Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved forest, altitude 2350 m, 21 August 2022, P. Zhang 4728 (Holotype, MHHNU 11228, GenBank Acc. No.: ITS = PP467126, nrLSU = PP493457, *tef1-α* = PP480349).

Description: *Basidiomata* 11 cm high and 4.5 cm broad, repeatedly branched, obovate in outline. *Stipe* 3 × 2 cm, single to falsely fasciculate, fleshy, solid, rounded to rooting at base, sometimes with very few abortive branchlets, off-white (1A1) where protected, gradually grayish yellow (2B5), with common areas of mustard yellow (3B6); flesh off-white (1A1), dry, drying punky. *Major branches* 3–4, thick, fleshy, ascending, mustard yellow (3B6), bruising slowly to dull yellow (3B3); *Branches* in 3–5 ranks, terete, often obscurely rugulose; flesh ivory (4B3); internodes diminishing gradually upwards; axils rounded; *Apices* slender, double-dichotomous, somewhat prolonged, greenish yellow (1A2) when young, finally concolorous with branches. Odor weakly

fragrant, aromatic; taste negligible to faintly astringent.

Basidiospores [60/2/2](8.1–)8.1–10.7(–12.8) × (4.7–)5.0–6.6(–7.0) µm, $L_m = 9.35$ µm, $l_m = 5.65$ µm, $Q = (1.46–)1.47–1.85(–2.03)$, $Q_m = 1.66 \pm 0.14$, ellipsoid, roughened in profile, wall up to 0.5 µm thick; hilar appendix broad, with no throat, ornamentation of complex meandering and anastomosing ridges and warts up to 0.3 µm high. **Basidia** 50–58 × 7–8 µm,

clavate, clamped, hyaline; sterigmata 4, spindly, straight. **Subhymenium** extensive, hyphal; **Hymenium** unthickening; **Tramal hyphae of stipe** 3.5–8 µm wide, hyaline, clamped, hardly inflated, thin-walled, parallel, not agglutinated or adherent; ampulliform clamps common, up to 12 µm broad, not abrupt, somewhat thick-walled, (wall up to 1.5 µm thick), unornamented.

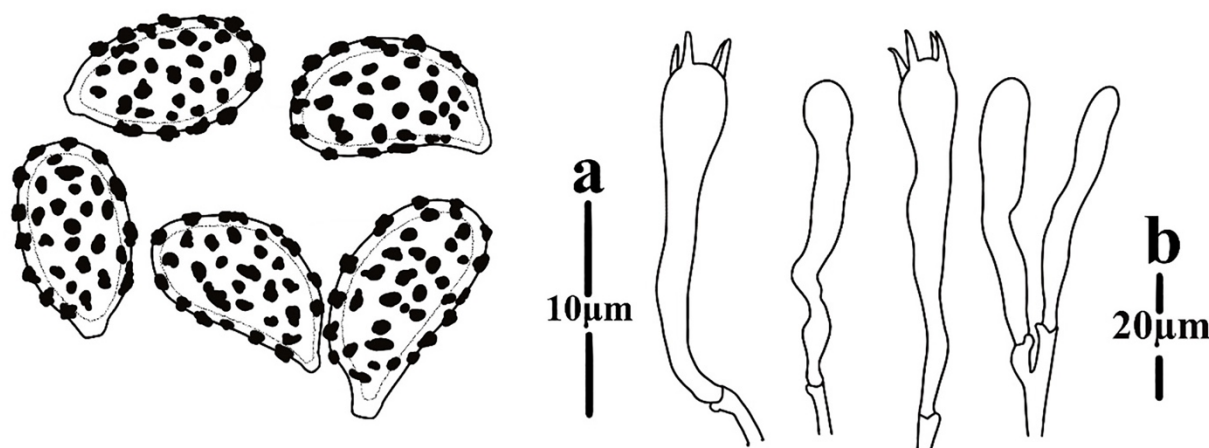


Fig. 136 Microscopic features of *Gom. luteolus* (MHHNU 11228). a basidiospores; b basidia. Scale bars: a = 10 µm, b = 20 µm.

Ecology: Solitary or gregarious on soil in the forests with *Castanopsis*, *Fagaceae* and *Pinaceae*, or in mixed forests.

Distribution: In southwestern China (Yunnan).

Additional materials examined: CHINA, YUNNAN PROVINCE: Xishuangbanna, Jinghong City, Menglun Town, near the Kino Gully, in the broad-leaved forest, altitude 1000 m, 14 August 2005, P. Zhang 453 (MHHNU 6953); same city, purchased at the Mushroom Market, 9 August 2001, Z. L. Yang 3171 (HKAS 38348); Pu'er, Menglang Town, in a forest dominated by *Pinaceae*, altitude 980 m, 30 July 2017, P. Zhang 2629 (MHHNU 9129); Wenshan, Malipo County, Donggan Town, Matong Village, in broad-leaved forest with *Fagaceae*, altitude 2000 m, 5 August 2018, P. Zhang 3344 (MHHNU 9844), P. Zhang 3345 (MHHNU 9845); Chuxiong, Zixi Mountain, in broad-leaved forests, altitude 2200 meters, 25 August 2022, P. Zhangping 4788 (MHHNU 11288); same location, in mixed forests dominated by *Fagaceae* and *Pinaceae*, altitude 2250 meters, 24 August 2022, P. Zhangping 4781 (MHHNU 11281); same location, 28 July 2021, Z. H. Chen 32957 (MHHNU 32957); Chuxiong, Mouding County, Huafo Mountain, in a broad-leaved forest, altitude 2350 m, 21 August 2022, P. Zhang 4731 (MHHNU 11231), P. Zhang 4732 (MHHNU 11232); same location, Chuxiong, Mouding County, Huafo Mountain, 27 July 2021, Z. H. Chen 32923 (MHHNU 32923).

Commentary: Young *Gom. luteolus* presents a cream color, which deepens to purplish-brown upon maturation. Although it might resemble *Gom. asiaticus*, the distinguishing factor lies in the wider and shorter basidiospores of *Gom. luteolus*. Another similar species is the *Gom. latispoluteolus*, sharing similarities in basidiospores size and ornamentation. However, *Gom. latispoluteolus* deepens to a dull yellow color upon maturation and lacks the purple hue seen in *Gom. luteolus*.

IV Three genera, *Gloeocantharellus*, *Gautieria* and *Turbinellus*, within Gomphaceae consist only of species with non-ramarioid basidiomata

Gautieria Vittad., Monogr. Tuberac. (Milano): 25 (1831)

Gautieria is a genus within Gomphaceae with over 50 recorded species to date (Kirk et al. 2008; Kirk 2024). It has distinctive morphological characteristics: sequestrate (truffle-like) basidiomata with thin and easily evanescent peridium, gleba with labyrinthine locules, tramal plates in coralloid type of development, and colored basidiospores with longitudinal ribs. SODs and two-gene phylogenetic analysis in our study suggest that *Gautieria* is closely related to the subgen. *Ramaria*, specifically forming a sister group to *Ramaria* ser. *Hemirubellae*. Ecologically, some species in this genus have been identified as ectomycorrhizal associates of plants such as *Quercus*, *Picea*, and *Pleurocospora*, potentially playing a significant role in forest ecosystems (Yang 2023).

Seven species of *Gautieria* have been identified in China, including:

- (1) *Gau. chengdensis* J.Z. Ying, Acta Mycol. Sin. 3(2): 89 (1984)
- (2) *Gau. globispora* K. Tao, Ming C. Chang & B. Liu, Shanxi Univ. J., Nat. Sci. Ed. 19: 82 (1996)
- (3) *Gau. hubeiensis* K. Tao, Ming C. Chang & A-S. Xu, Journal of Shanxi University, Natural Science 19(3): 320 (1996)
- (4) *Gau. mianjin* Kun L. Yang, Xiao Liu & Zhu L. Yang, in Yang, Zhang, Wang, Liu & Yang, Phytotaxa 594(2): 123 (2023)
- (5) *Gau. shennongjiaensis* K. Tao, Ming C. Chang & B. Liu, Journal of Shanxi University, Natural Science 19(3): 320 (1996)
- (6) *Gau. sinensis* J.Z. Ying, Mycotaxon 54: 299 (1995)
- (7) *Gau. xinjiangensis* T. Bau, Mycotaxon 123: 289 (2013)

To keep the nomenclatural and taxonomic stability, our data suggested that it is ideal to treat the genus *Gautieria* as a synonym of *Ramaria*. However, due to the issue of

nomenclatural priority — *Gautieria* (established in 1831) predates *Ramaria* (established in 1851)—a formal decision regarding the legitimacy and typification of *Ramaria* is necessary before such a transfer can be enacted. Once the nomenclatural status of *Ramaria* is resolved, these species should be transferred to the genus *Ramaria*.

***Gloeocantharellus* Singer, Lloydia 8(3): 140 (1945)**

Gloeocantharellus is a small genus within Gomphaceae, with over 20 recorded species to date, mostly from the southern Hemisphere (Kirk et al. 2008; Kirk 2024). It has cantharelloid basidiomata with yellow to pale yellow-brown ornamented basidiospores. SOGs and two-gene phylogenetic analyses in our study suggest that *Gloeocantharellus* forms a single clade and be a sister clade to *Gloeocantharellus*, *Gautieria*, and *Turbinellus* group. However, this genus is not a monophyletic clade, as only one species was included in our SOGs and two-gene phylogenetic analysis.

Two species have been recorded in China (Deng and Li 2008; Song et al. 2019):

- (1) *Glo. neoehinosporus* Ming Zhang & T.H. Li, in Song et al., Sydowia 71: 172 (2019)
- (2) *Glo. persicinus* T.H. Li, Chun Y. Deng & L.M. Wu, Mycotaxon 106: 450 (2009) [2008]

***Turbinellus* Earle, Bull. New York Bot. Gard. 5: 407 (1909)**

Turbinellus is a monophyletic clade within Gomphaceae, with over 17 recorded species to date (Kirk et al. 2008; Kirk 2024). It has cantharelloid basidiomata with different colors and ornamented basidiospores. SOGs and two-gene phylogenetic analyses in our study suggest that *Turbinellus* forms a single clade and close to *Ramaria* ser. *Pallidolilacinae*.

11 species have been recorded in China (Fan et al. 2023):

- (1) *T. flavidus* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 15 (2023)
- (2) *T. fulvus* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 16 (2023)
- (3) *T. imbricatus* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 17 (2023)
- (4) *T. longistipes* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 19 (2023)
- (5) *T. parvisporus* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 20 (2023)
- (6) *T. solidus* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 21 (2023)
- (7) *T. squamosus* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 23 (2023)
- (8) *T. szechwanensis* (R.H. Petersen) Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 24 (2023)
- (9) *T. tomentosipes* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 25 (2023)
- (10) *T. verrucosus* Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 27 (2023)
- (11) *T. yunnanensis* (R.H. Petersen & M. Zang) Xue Ping Fan & Zhu L. Yang, in Fan, Liu & Yang, J. Fungi 9(6, no. 626): 28 (2023)

For nomenclatural and taxonomic stability and decreasing the number of unnecessary new genera, our phylogenetic analyses suggested that *Turbinellus* should be treated as a synonym of *Ramaria*. However, *Turbinellus* exhibits a cantharelloid-gomphoid morphology that differs significantly from the typical ramarioid morphology of *Ramaria*. To

maintain morphological coherence and avoid taxonomic confusion, we have not formally transferred *Turbinellus* species into *Ramaria* at this time. Once the morphological boundaries of *Ramaria* are more clearly defined and broadly accepted, these species should be transferred to the genus *Ramaria*.

Discussion

This study provides phylogenetic analysis of the family Gomphaceae, utilizing both phylogenomic (1025 single-copy orthologous genes) and two-loci (ITS and nrLSU) datasets. Crucially, our data demonstrate that the traditionally classified Gomphaceae is a non-monophyletic group, necessitating taxonomic revision. Specifically, *Ramaria* subgenus *Lentoramaria* is phylogenetically distant from the Gomphaceae, leading to its segregation into five new genera (*Acutiramaria*, *Brachyramaria*, *Gracimaria*, *Lentoramaria*, and *Rubellaria*). Furthermore, we confirmed that *Gautieria* and *Turbinellus* are nested within the reconstructed *Ramaria* clade, thereby validating the monophyly of the Gomphaceae under a revised circumscription that encompasses the genera *Gloeocantharellus*, *Gomphus*, and *Ramaria* s.l. Overall, we identified and described a total of 113 species, including the establishment of five new genera, 68 new species, and 13 new combinations.

The need for a comprehensive systematic revision stems from the long-standing phylogenetic uncertainties that have historically challenged the Gomphaceae classification, evident in decades of morphological and early molecular studies (Donk 1961; Petersen 1971a, 1988b; Pine et al. 1999; Giachini et al. 2010). Although Gomphaceae is a morphologically diverse family, its monophyly was not consistently supported in previous studies. Molecular studies, such as that by Giachini et al. (2010), who used nuclear 25S rDNA, and mitochondrial 12S rDNA and *atp6* sequences, indicated that the genera *Gautieria*, *Gloeocantharellus*, *Gomphus*, *Turbinellus*, and terricolous species of *Ramaria* formed a highly supported monophyletic clade, while the genus *Phaeoclavulina* (comprising all echinulate-spored *Ramaria*) of Gomphaceae was resolved as a separate monophyletic clade, since then, *Ramaria* subgen. *Echinoramaria* has been treated as genus *Phaeoclavulina*. Xu et al. (2022) and Peng et al. (2023), who established genera *Gomphocantharellus* and *Luteodorsum*, respectively, also observed that these four genera, together with most species of *Ramaria*, formed well-supported monophyletic clades. However, these authors also placed genera *Luteodorsum* and *Phaeoclavulina* within the family Gomphaceae, while *Gomphocantharellus* placement remained uncertain. Compared with previous studies, our study represents a major systematic advancement by definitively resolving the systemic placement of all major clades and clarifying the uncertain generic boundaries left by these prior analyses.

Despite the major resolution achieved, further research is needed to solidify the classification. The tentative division into series, particularly where clades are represented by single species (e.g., ser. *Leiosporae* and ser. *Robustipurpurea*), necessitates additional work. More extensive sampling of specimens across these poorly-represented clades, coupled with additional genome sequence data, is required to finalize their proper taxonomic ranks and ensure robust systematic resolution. Furthermore,

future efforts should focus on exploring the full genomic potential of the newly segregated genera outside of Gomphaceae (*Acutiramaria* to *Rubellaria*) to confirm their precise placement within the order Gomphales.

However, resolving the phylogenetic relationships is only the first step; these systematic insights inevitably bring to the forefront several critical and long-standing taxonomic challenges that must be addressed to stabilize the classification of Gomphaceae.

Key taxonomic challenges in Gomphaceae

(1) Nomenclatural priority and validity of genera in Gomphaceae

From a nomenclatural perspective, the valid genus names *Gloeocantharellus* and *Turbinellus* are both more recent than *Ramaria*, whereas *Gautieria* and *Gomphus* predate *Ramaria*. The nomenclature of both *Gomphus* and *Ramaria* has undergone considerable revision over time. *Gautieria* was established by Vittadini in 1831 (based on the type species *G. morchelliformis* Vittad.), in which more than 70 species have been recorded (Kirk 2024). Species within this genus typically exhibit a truffle-like basidioma with a thin and easily evanescent peridium, gleba with labyrinthine locules, hymenophore with coralloid development, and colored basidiospores with longitudinal ribs (Vidal et al. 2023; Yang 2023). *Gomphus*, proposed by Persoon (1797b), initially included many species, but its nomenclature and circumscription have since undergone multiple adjustments and revisions. *Gomphus* has been subdivided into genera *Gloeocantharellus*, *Gomphus* s.s., *Phaeoclavulina*, and *Turbinellus*, and included only seven species in China (Liu et al. 2022; Fan et al. 2023). *Gloeocantharellus*, a genus proposed by Singer (1945), is a relatively small genus in the Gomphaceae with *G. purpurascens* (Hesler) Singer as the type species and includes 19 recorded species (Kirk 2024). *Gloeocantharellus* is characterized by a small basidioma, pitted hymenial surface, abundant gelatinous hyphae, and with most species in this genus possessing gloeocystidia. *Turbinellus* was established by Earle (1909) with *T. floccosus* (Schwein.) Earle ex Giachini & Castellano as its type species.

The history of the generic name *Gomphus* has involved several proposals and revisions. In 1796, Persoon proposed the genus *Merulius*, which included *Merulius violaceus* (= *M. clavatus*) (Persoon 1797a). In 1797, he elevated the name “*Gomphus*” to the generic rank without delineating any species within this newly established genus, although the generic name was validly published. In 1801, he placed *Gomphus* within the genus *Merulius* as sect. *Gomphus*, which included two taxa [*M. clavatus* var. *violaceus* and *M. clavatus* var. *spadiceus* (= *Clavaria truncata* Schmidel)]. In 1822, Persoon again raised *Gomphus* to the generic rank and described five species within the genus, including *G. truncatus* (= *M. clavatus*) (Persoon 1822). In 1821, Fries recognized *Gomphus* as a tribe within the genus *Cantharellus* Adans. ex Fr. (Fries 1821), but in the same year, Gray accepted the genus name proposed by Persoon and designated *G. clavatus* as its type species (Gray 1821). The generic name was initially frequently cited as “*Gomphus* (Pers.) Gray” or “*Gomphus* Pers. ex Gray”. In 1983, the Thirteenth International Botanical Congress (Stafleu 1972) recognized that the genus name was validly published in 1797, leading to the revision of the authority citation to *Gomphus*

Pers.

Similarly, the name *Ramaria* has undergone multiple revisions. Although the genus name *Ramaria* was officially approved by the Eleventh International Botanical Congress as validly published in 1851 (Stafleu 1972), it is noteworthy that as early as 1821, the British botanist S.F. Gray legitimized the name *Ramaria*, proposed by Holmskjöld (Holmskjöld 1790), for a group with branched basidiomatas. This validation marked the initial recognition of the genus *Ramaria*, but the species group was not elevated to the generic rank, because the genus encompassed not only species with white basidiospores (distinct from presently accepted *Ramaria* species) but also included the type species *R. coralloides* var. *alba* [= *Clavaria botrytis* Pers.]. Subsequently, Corner and others used the generic name *Ramaria* S.F. Gray emend. Donk in their works (Corner 1950, 1970). However, in 1954 and 1964, Donk recommended retaining the genus name as *Ramaria* (Holmskj. ex Fr.) Bonord. emend. Donk (Donk 1954, 1964), which was approved by the Eleventh International Botanical Congress in 1969 (Stafleu 1972). Consequently, the genus named *Ramaria* Fr. ex Bonord. was formally recognized. Nevertheless, even in 1970, Corner still considered *Ramaria* S.F. Gray as the valid name for the genus *Ramaria*, thus tracing its establishment to 1821 (Corner 1970).

Consequently, the genus *Gomphus* was the first to be formally proposed among the genera *Gautieria*, *Gloeocantharellus*, *Gomphus*, *Ramaria* and *Turbinellus*. Based on the phylogenomic position of the type species for genus *Ramaria* s.l. and other genera within the Gomphaceae, continued use of the genus name *Ramaria* is untenable according to the code. There are two ways to rectify this nomenclatural inconsistency. The first is to elevate the monophyletic sister clades within the genus *Ramaria* to the generic rank, thereby recognizing them at the same taxonomic rank alongside *Gautieria*, *Gomphus*, and *Gloeocantharellus* within the family. The second solution entails comparing the validly published names of the four genera and, according to the principle of nomenclatural priority based on the earliest publication date, modifying the genus names accordingly. If the sister clades of the four genera were recognized at generic rank, the Gomphaceae would gain more than 30 new genera. Considering the chronological order of validly published generic names, the genus *Ramaria* predates *Gloeocantharellus* and *Turbinellus*, but *Gomphus* has nomenclatural priority over all of these names. However, *Gomphus* currently comprises only a small number of species, whereas *Gautieria* and *Ramaria* encompass a diverse range of species, with more than 300 species requiring taxonomic revision. *Ramaria* as a genus would no longer exist, requiring extensive publication of new combinations in *Gomphus*. For nomenclatural and taxonomic stability and for decreasing the number of unnecessary new genera, it is suggested that *Gautieria* and *Turbinellus* should be treated as a synonym of *Ramaria*.

(2) Rank delimitation issues in *Ramaria*

Typically, hierarchical classifications within a genus proceed as subgenus, sections (or subsection), and series in succession. In this study, we followed both the traditional taxonomic framework and the results of our phylogenomic analyses. Apart from transferring some ramarioid species, which were previously placed in *Ramaria*, to *Gomphus*, we did not modify the two currently recognized subgenera:

subgen. *Ramaria* (characterized by striate basidiospores) and subgen. *Laeticolora* (characterized by smooth or verrucose basidiospores). Most of the series represent small clades with high support, but we consider them insufficiently robust to be elevated to sections. For example, within subgen. *Ramaria*, our results suggest two potential sections: a striate-spored section (including ser. *Botrytes* and ser. *Hemirubellae*) and a sequestrate section (including ser. *Gautieria*). Within subgen. *Laeticolora*, three sections could be recognized: a smooth-spored section (ser. *Leiosporae*), a verrucose-spored section (comprising most series), and a robustipurpurea section (currently only *R. robustipurpurea*). However, we argue that such a division does not substantially improve resolution compared with maintaining subgen. *Laeticolora* as a whole, because two of the proposed sections (ser. *Leiosporae* and ser. *Robustipurpurea*) each contain only a single species. More extensive sampling of specimens in these clades as well as additional genome sequence data on such specimens are needed to finalize their proper taxonomic ranks. In addition, Corner (1970) also employed the rank of “series” to represent different *Ramaria* clades. For these reasons, we adopt “series” as the appropriate rank for delimiting clades at the immediate above-species level in this study. Accordingly, in revised circumscription, *Ramaria* was divided into 29 series (including ser. *Gautieria* and ser. *Turbinellus*) and all of these series were consistently resolved within the monophyletic Gomphaceae.

(3) Ecological characteristics as diagnostic traits in Gomphaceae

In this study, ecological data were recorded in terms of fruiting pattern (solitary or gregarious), substrate preference (lignicolous or terrestrial), forest type (mixed, coniferous, or broad-leaf), and fruiting season (summer, autumn, or spring). Within Gomphaceae, most species are terrestrial and occur either solitarily or gregariously. Several genera established in this study, including *Lentoramaria*, were previously assigned to Gomphaceae; however, their species are mostly lignicolous and gregarious, and our phylogenomic analyses confirmed that they do not belong to Gomphaceae. This indicates that ecological traits can reflect taxonomic boundaries. In addition, some taxa in Gomphales, such as *Acutiramaria* and *Gracimaria*, are typically found in coniferous or mixed forests but rarely occur in broad-leaf forests. Furthermore, the majority of species fruit in summer or autumn, a few produce basidiomata in spring. These ecological features thus provide useful diagnostic traits for distinguishing some taxa within the family.

The rearrangements within Gomphaceae

In the present study, Gomphaceae formed a highly supported monophyletic clade within Gomphales, comprising genera *Gautieria*, *Gloeocantharellus*, *Gomphus* s.l., *Ramaria* s.l. and *Turbinellus*. Phylogenetic analyses reveal several well-supported lineages within the family: *Gloeocantharellus* formed a separate monophyletic clade. *Gautieria* formed a monophyletic clade together with ser. *Hemirubellae*. *Gomphus* clustered with the purple, clamps, ramarioid species to form a monophyletic clade, whereas *Turbinellus* also formed a monophyletic clade with pale purple species lacking clamps (ser. *Pallidolilacinae*). These results indicate clear phylogenetic structuring and justify the need to reassess genus-level circumscription within the family.

Conclusion

By integrating our findings with previous studies (Pine et al. 1999; Humpert et al. 2001; Giachini 2004a; Xu et al. 2022; Peng et al. 2023), we propose a new circumscription of Gomphaceae that ensures molecular monophyly.

(1) The rearrangements within Gomphaceae

The redefined family primarily includes the genera *Gloeocantharellus*, *Gomphus*, and the revised circumscription of *Ramaria*, reflecting both phylogenetic relationships and ecological coherence.

(2) Placement of some ramarioid species within *Gomphus*

Some ramarioid species are placed in *Gomphus*. They are *Gomphus asiaticus*, *G. asiaticaviolaceus*, *G. bicolor*, *G. discopurpurea*, *G. fusisporus*, *G. latispoluteolus* and *G. luteolus*. The reasons for this placement are as follows:

(i) they cluster with *Gomphus* in the phylogenomic phylogeny and most exhibit purple tones and clamps, similar to the type species *Gomphus clavatus*.

(ii) as the type genus of Gomphales established in 1753, *Gomphus* cannot be easily merged into *Ramaria* due to nomenclatural priority.

(3) *Gautieria* and *Turbinellus* are merged into *Ramaria*

The reasons are as follows:

(i) *Turbinellus*, which was established in 1905 by Earle, later than *Ramaria* (established in 1851), clusters with several *Ramaria* series with high support.

(ii) Although *Gautieria* was established in 1831, earlier than *Ramaria*, we propose its transfer, as argued in the Discussion section, for the sake of taxonomic stability and to limit the creation of unnecessary new genera. We consulted Canadian mycologist Scott A Redhead, who suggested that it may be best to proceed boldly with the combination, conserving *Ramaria* over *Gautieria*. Accordingly, we finally propose that *Gautieria* and *Turbinellus* be included within *Ramaria*.

(4) Revised outline of Gomphaceae

An outline of the revised system of Gomphaceae is summarized below.

Outline of Gomphaceae

Gomphaceae Donk

(1) *Gloeocantharellus* Singer

(2) *Gomphus* Pers.

(3) *Ramaria* Fr. ex Bonord.

(i) Subgen. *Ramaria* Fr. ex Bonord

Ser. *Botrytes* Corner

Ser. *Hemirubellae* P. Zhang & J. Zhong

Ser. *Gautieria* (Vittad.) P. Zhang & J. Zhong

= *Gautieria* Vittad.

(ii) Subgen. *Laeticolora* Marr & D.E. Stuntz

Ser. *Brunnescientaurantiae* P. Zhang & J. Zhong

Ser. *Conjunctipesae* P. Zhang & J. Zhong, Ser. nov

Ser. *Flavae* (Franchi & M. Marchetti) P. Zhang & J. Zhong

Ser. *Flavescentoides* P. Zhang & J. Zhong

Ser. *Formosae* Corner

Ser. *Gelatinosae* P. Zhang & J. Zhong

- Ser. *Laetae* P. Zhang & J. Zhong
 Ser. *Laeviformosoides* P. Zhang & J. Zhong
 Ser. *Leiosporae* P. Zhang & J. Zhong
 Ser. *Lineariflavae* P. Zhang & J. Zhong
 Ser. *Longisporae* P. Zhang & J. Zhong
 Ser. *Luteae* (Franchi & M. Marchetti) P. Zhang & J. Zhong
 Ser. *Nanisporae* P. Zhang & J. Zhong
 Ser. *Neoformosae* (Franchi & M. Marchetti) P. Zhang & J. Zhong
 Ser. *Pallidochraceus* P. Zhang & J. Zhong
 Ser. *Pallidolilacinae* P. Zhang & J. Zhong
 Ser. *Pseudobotrytes* (Franchi & M. Marchetti) P. Zhang & J. Zhong
 Ser. *Pseudocystidiophorae* P. Zhang & J. Zhong
 Ser. *Robustipurpureae* P. Zhang & J. Zhong
 Ser. *Roseobrunneae* P. Zhang & J. Zhong
 Ser. *Sanguinipesae* P. Zhang & J. Zhong
 Ser. *Semigelatinosae* P. Zhang & J. Zhong
 Ser. *Sparsiaggregatae* P. Zhang & J. Zhong
 Ser. *Spinulosae* (Franchi & M. Marchetti) P. Zhang & J. Zhong
 Ser. *Turbinellus* (Earle) P. Zhang & J. Zhong = *Turbinellus* Earle
 Ser. *Zebrisporae* P. Zhang & J. Zhong

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Conflict of interest statement

The author list includes members of the Editorial Board of Fungal Diversity. They were not involved in the journal's review of, or decisions related to, this manuscript. The authors declare no competing interests.

Data availability

The DNA sequences obtained in this study have been submitted to GenBank.

Supplementary Information

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