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Boletoid fungi (Boletaceae, Basidiomycota) of protected areas of Kon Tum Plateau (Central Highlands of Vietnam)

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Summary. The article continues the series of publications devoted to the boletoid fungi of Vietnam. It summarizes the results of the observation of their diversity in three nature protected areas of the Central Highlands (Tây Nguyên) – Kon Ka Kinh National Park, Kon Chu Rang (Kon Chư Răng) Nature Reserve and Kon Plong Protected Forest, where middle-mountain evergreen broad-leaved and coniferous-deciduous forests prevail at altitudes of 900–1500 m. An annotated list of 22 revealed species is presented. Of these, two species (*Fistulinella aurantiiflava* and *Tylopilus subotsuensis*) have been recently described from this territory as new to science. *Hortiboletus rupicapreus* is reported “ad interim”. Information on eight species (*Aureoboletus sinobadius*, *Hourangia nigropunctata*, *Ionosporus longipes*, *Neoboletus multipunctatus*, *Phylloporus luxiensis*, *Pulveroboletus subrufus*, *Tylopilus atripurpureus*, *T. atroviolaceo-brunneus*) is published for the first time for Vietnam. *Strobilomyces* aff. *echinocephalus*, *S.* aff. *glabriceps*, and *Tylopilus* aff. *balloui* (two different lines) are close to known species but genetically not identical. Six more specimens are identified only to the genus, and they probably represent species new to science. The color photographs of new to Vietnam and noteworthy species are presented. The nucleotide sequences obtained during the study were deposited in NCBI GenBank.

Болетовые грибы (Boletaceae, Basidiomycota) особо охраняемых природных территорий плато Контум (Центральное нагорье Вьетнама)

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Ключевые слова: биоразнообразие, болетовидные базидиомицеты, Конкакин, Конплонг, Контгыранг, особо охраняемые природные территории, тропические леса, Тэйнгун, Центральное нагорье Вьетнама.

Аннотация. Статья продолжает серию работ, посвященных болетовым грибам Вьетнама. Здесь обобщены результаты изучения разнообразия этой группы грибов трех охраняемых природных территорий Центрального нагорья (Тэйнгуэи) – национального парка Конкакин, природного заповедника Контгыранг и охраняемого лесного массива Конплонг, где на высотах 900–1500 м преобладают среднегорные широколиственные и хвойно-широколиственные леса. Приводится аннотированный список 22 идентифицированных видов. Из них два недавно описаны с этой территории как новые для науки виды (*Fistulinella aurantioflava* и *Tylopilus subotsuensis*). *Hortiboletus rupicapreus* приводится “ad interim”. Информация о восьми видах (*Aureoboletus sinobadius*, *Hourangia nigropunctata*, *Ionosporus longipes*, *Neoboletus multipunctatus*, *Phylloporus luxiensis*, *Pulveroboletus subrufus*, *Tylopilus atripurpureus*, *T. atroviolaceobrunneus*) публикуется впервые для Вьетнама. *Strobilomyces* aff. *echinocephalus*, *S.* aff. *glabriceps* и *Tylopilus* aff. *balloui* незначительно отличаются генетически от соответствующих известных видов. Еще шесть образцов определены только до рода и, вероятно, представляют новые для науки виды. Приводятся цветные фотографии новых для Вьетнама и редких видов. Нуклеотидные последовательности, полученные в ходе исследования, депонированы в GenBank NCBI.

Introduction

This article continues the series of publications devoted to the diversity of the boletoid fungi in Vietnam (Pham et al., 2018; Pham, Morozova, 2020). The results of the work in three nature protected areas of the Central Highlands (Tây Nguyên) – Kon Chu Rang (Kon Chư Răng) Nature Reserve, Kon Ka Kinh National Park and Kon Plong Protected Forest – are summarized here. Before the beginning of our research, there was no information on the mycobiota of this territory. Then, the data on the agaricoid genera *Entoloma*, *Volvariella*, *Pluteus* were published (Morozova et al., 2018; Malysheva et al., 2019, 2020).

An annotated list of 22 species of Boletaceae is presented here. Of these, two species (*Fistulinella aurantioflava* and *Tylopilus subotsuensis*) have been recently described by us from this territory as new to science (Crous et al., 2020, 2021). *Hortiboletus rupicapreus* is reported here “ad interim”, it will be published soon. Eight species (*Aureoboletus sinobadius*, *Hourangia nigropunctata*, *Ionosporus longipes*, *Neoboletus multipunctatus*, *Phylloporus luxiensis*, *Pulveroboletus subrufus*, *Tylopilus atripurpureus*, and *T. atroviolaceobrunneus*) are published for the first time for Vietnam. But most of them (by the exclusion of *Aureoboletus sinobadius* and *Tylopilus atripurpureus*) were reported previously in the manuscript of the dissertation work of the first author (Pham, 2020).

Materials and methods

Collections were made by route method in different types of tropical forests on Kon Tum plateau in 2015–2017 in course of the investigation of mycobiota of the Central Highlands (Tây Nguyên).

The information on the nature conditions of the territories studied is provided below.

Kon Ka Kinh National Park

Kon Ka Kinh National Park (Vườn quốc gia Kon Ka Kinh) is located in the northern part of Gia Lai Province (Mang Yang County, A Yun Commune) between 14.15°N–14.5°N and 108.25°E–108.45°E and covers an area of 417.8 km². About 80 % (331.46 km²) of the park's territory is covered with forests. The territory of the park lies between Pleiku and Kon Ha Nung plateaus and has mountainous terrain with an average altitude of 1200–1500 m a. s. l. (the highest Kon Ka Kinh – 1748 m). The rivers flowing through the park belong to the basins of the Ba, Pne, and A Yun rivers. The park's climate is tropical monsoon, with distinct rainy (May – November) and dry (December – April) seasons. The average annual temperature ranges from 21 to 25 °C. The average annual precipitation is from 2000 to 2500 mm, the peak of precipitation falls in July–August (400–450 mm). There is practically no precipitation in January – February (Sourcebook of Existing ..., 2004; Ha et al., 2011, 2014).

The forest vegetation of Kon Ka Kinh National Park is represented by three main types (Thai, 1978; Le et al., 2000). The most widespread are mountain evergreen broad-leaved forests, which occupy heights of 900–1000 m a. s. l. and higher. They are characterized by the dominance of species of Fagaceae (*Castanopsis*, *Lithocarpus*, *Quercus*), Lauraceae, Euphorbiaceae, Meliaceae, Sterculiaceae, Theaceae, Rubiaceae. In mountain evergreen mixed forests found south of the Kon Ka Kinh Mt, at altitudes from 1300 m, in addition to species from the families Fagaceae, Theaceae, Euphorbiaceae, Hamamelidaceae, Elaeocarpaceae, Myrtaceae, and Meliaceae, species of conifers present (*Fokienia hodginsii*, *Dacrycarpus imbricatus*, *Dacrydium*

elatum, *Nageia fleuryi*, *Podocarpus neriifolius*). Below 900 m a. s. l., low-mountain evergreen broad-leaved forests are developed, dominated by Dipterocarpaceae (*Shorea siamensis*, *S. roxburghii*), Fabaceae, Irvingiaceae, Euphorbiaceae, Moraceae, Burseraceae, Lauraceae, Apocynaceae, Meliaceae, Fagaceae, and Magnoliaceae. Rather large area is occupied by plantings of *Pinus latteri*.

Kon Chu Rang Nature Reserve

The KBTTN Kon Chu Răng is located in the northeastern part of Gia Lai Province (K'Bang District, Son Lang Commune), between 14.5°N–14.58°N and 108.5°E–108.65°E, and is bordered by the provinces of Binh Dinh, Quang Ngai, and Kon Tum. The area of the reserve is 159 km², of which 156.1 km² (99 %) are primary and intact forests. The relief of the reserve is mostly hilly, mountainous in the northern part, with heights from 800 to 1452 m a. s. l. (Kon Chur Răng). The average annual temperature is about 21 °C (maximum in May +28 °C, minimum in January +12 °C). The average annual precipitation is about 1900–2000 mm, the peak of precipitation falls in September (340 mm). The dry season is relatively short, with up to 60 mm of precipitation per month in January – April (New et al., 2002; Sourcebook of Existing ..., 2004). Numerous rivers flowing through the reserve belong to basin of the Kon River (Sông Kôn), which has a number of waterfalls, the most famous and tallest of which is 50 m high.

The main forest type is middle-mountain evergreen broad-leaved and mixed forest distributed at elevations between 900 and 1500 m in the northwest of the nature reserve. Canopy cover of this forest type is 70 to 80 %, and the tree flora is dominated by species from the Fagaceae (*Lithocarpus*, *Quercus*, *Castanopsis*), Lauraceae, Fabaceae, Clusiaceae, Myrtaceae, Ericaceae, Burseraceae, and Magnoliaceae, mixed with gymnosperms (*Dacrycarpus imbricatus*, *Dacrydium elatum*). Lowland evergreen forest occurs at elevations below 900 m. Only 2 % of the nature reserve is covered by secondary vegetation, mainly scrub with scattered trees.

Kon Plong Protected Forest

The Kon Plong Protected Forest is located in the northeast of Kon Tum Province (Kon Plong County), within the state forestry enterprises of Mang Canh II, Tan Lap, and the Ngok tem (Ngok tem) Water Protection Forest. The massif has an area of 650.8 km² and is located on the highly dissected mountain

basalt plateau Kon Ha Nung (Kon Hà Nùng), at an altitude of 1100 to 1757 m a. s. l. The studied territory is located in the basin of the Lo (Đắk Lo), Te (Nước Che) rivers and the lower reaches of the Khe (Đắk Khê) river within 14.7125°N–14.7589°N and 108.3°E–108.3233°E. The climate is characterized by moderate temperatures (average annual temperature is about +18 °C, and the coldest month +16 °C) and heavy rainfall (up to 2800 mm per year).

The vegetation cover above 1000 m a. s. l. is dominated by middle-mountain evergreen mixed forests, the upper tier of which is dominated by Fagaceae (*Lithocarpus*, *Quercus*, *Castanopsis*), Lauraceae, Hamamelidaceae, Theaceae, Podocarpaceae (*Dacrycarpus imbricatus*, *Dacrydium elatum*, *Podocarpus neriifolius*), Pinaceae (*Pinus dalatensis*, *Keteleeria evelyniana*), Cupressaceae (*Fokienia hodginsii*), etc. There are areas of monodominant coniferous forests with *Pinus latteri*. At altitudes up to 900–1000 m a. s. l. low-mountain evergreen broadleaf forests are developed with the participation of Dipterocarpaceae (*Shorea siamensis*, *Parashorea stellata*, *Dipterocarpus obtusifolius*), Fagaceae, Myrtaceae, Sterculiaceae, Annonaceae, etc. On a large area, natural forests are disturbed by economic activity and are replaced by secondary forests, bamboo, shrub and herbaceous communities (Eames et al., 2001; Pham et al., 2001).

Morphological study

Macromorphological features were studied on the basis of fresh and dried material, as well as through the analysis of photographs and descriptions taken in the field.

Micromorphological structures were studied using herbarium material. The collected specimens were examined using light and electron microscopy, as well as by analyzing DNA sequences (ITS and *tefla* sites). Microscopical characters were studied with a light Zeiss Axioscope A1 microscope with AxioCam1Cc 3 camera and program tools AxioVisionRel.4.6. (Carl Zeiss, Germany). Basidiospores, basidia, and hymenial cystidia were observed in squash preparations of small parts of the tubes in 5 % KOH. The pileipellis was examined on a radial section of the pileus, the stiptipellis – on longitudinal slice of the stipe in 5 % KOH. Basidiospore dimensions are based on 20 measurements, whereas cystidia and basidia dimensions are based on observing at least 10 structures per collection.

SEM photos were also used for the identification of material. They have been made by L. A. Kartseva on a scanning analytical electron microscope JEOL JSM-6390LA of Core Facility Centre ‘Cell and Molecular Technologies in Plant Science’ of Komarov Botanical Institute and by A. V. Alexandrova (Lomonosov State University) on scanning analytical electron microscopes JSM-6380LA and Camscan-S2 (Cambridge Instruments, 1990).

Molecular-genetic study

The molecular study is based on a phylogenetic species recognition (Taylor et al., 2000). To assess the taxonomic status of the identified phylogenetic lineages and put forward species hypotheses, we relied on the accepted boundaries of the possible variability of the ITS1-5.8S-ITS2 and *tefla* nDNA regions within the species (Petersen et al., 2008; Hughes et al., 2009).

DNA was extracted from herbarium material using NucleoSpin® Plant II kit (Macherey-Nagel, Düren, Germany). The ribosomal ITS1–5.8S–ITS2 region was amplified with primers ITS1F and ITS4B (Gardes, Bruns, 1993), and elongation translation factor (*tefla*) – with Boletaceae-specific primers EF1-B-F1 and EF1-B-R (Wu et al., 2014). PCR products were purified with the Fermentas Genomic DNA Purification Kit (Thermo Fisher Scientific, Waltham, MA) and sequenced on an ABI model 3130 Genetic Analyzer (Applied Biosystems, Waltham, MA). Raw data were edited and assembled in MEGA X (Kumar et al., 2018). Newly generated sequences were deposited in NCBI GenBank (Table).

Collections studied are kept in the Mycological Herbarium of the Komarov Botanical Institute (LE).

Results and discussion

Twenty-two species revealed in the Kon Tum plateau are listed below including ten species published for the first time for Vietnam (marked with “!”).

Annotated list of species of Boletoid fungi of the Kon Chu Rang Nature Reserve, Kon Ka Kinh National Park, and Kon Plong Protected Forest

Subfamily Austroboletoidae G. Wu et Zhu L. Yang

Fistulinella aurantioflava T. H. G. Pham, A. V. Alexandrova et O. V. Morozova: “Kon Ka

Kinh National Park, 14.217129°N, 108.310132°E, 1220 m a. s. l., on slopes of mountain, on soil in the tropical mountain polydominant forest with the participation of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. A. V. Alexandrova” (LE 315616) (Pham, 2020, as “*Pulveroboletus curtisii*”; Crous et al., 2021).

Subfamily Boletoidae

Subfamily Boletoidae Burnett
Hortiboletus rupicapreus Svetash., A. V. Alexandrova, O. V. Morozova et T. H. G. Pham, ad interim: “Kon Ka Kinh National Park, 14.219917°N, 108.325667°E, 1200 m a. s. l., ridges on slopes, on soil in tropical mountain forests dominated by Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 18 V 2016. A. V. Alexandrova” (LE 312677); *ibid.*, “14.205190°N, 108.316312°E, 1000 m a. s. l., on soil in plantations of *Pinus kesiya* with some Fagaceae. 15 V 2016. A. V. Alexandrova” (LE 312678).

Porphyrellus nigropurpureus (Hongo) Y. C. Li et Zhu L. Yang: “Kon Plong Protected Forest, Mang Canh Commune, 5 km north of Kondu Village, 14.73295°N, 108.31203°E, 1100 m a. s. l., on soil in polydominant rainforest with participation of Podocarpaceae, Magnoliaceae, Myrtaceae, Calophyllaceae, Elaeocarpaceae. 10 VI 2016. O. V. Morozova” (LE 315621).

! *Strobilomyces aff. echinocephalus* Gelardi et Vizzini: “Kon Ka Kinh National Park, 14.219917°N, 108.325667°E, 1200 m a. s. l., ridges on slopes, on soil in tropical mountain forests dominated by Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 18 V 2016. O. V. Morozova” (LE 312681, fig. 1a, b).

! *Strobilomyces aff. glabriceps* W. F. Chiu: “Kon Ka Kinh National Park, on slopes of the mountain, 14.217129°N, 108.310132°E, 1220 m a. s. l., on soil in tropical mountain polydominant forest with the participation of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. O. V. Morozova” (LE 312682, fig. 1c).

Strobilomyces seminudus Hongo: “Kon Ka Kinh National Park, 14.20414°N, 108.32143°E, 970 m a. s. l., on soil in a middle-mountain evergreen broadleaf forest with the participation of families Magnoliaceae, Myrtaceae, Theaceae, Lauraceae, Fagaceae. 20 V 2016. O. V. Morozova” (LE 315628, fig. 1d, e, f).

! *Tylophilus atripurpureus* (Corner) E. Horak: “Kon Ka Kinh National Park, 14.20414°N, 108.32143°E, 970 m a. s. l., on soil in a middle-mountain evergreen broadleaf forest with the

participation of families Magnoliaceae, Myrtaceae, Theaceae, Lauraceae, Fagaceae. 20 V 2016. O. V. Morozova” (LE 312683, fig. 1g).

! *Tylopilus atroviolaceobrunneus* Yan C. Li et Zhu L. Yang: “Kon Ka Kinh National Park, on soil

in a tropical middle-mountain polydominant forest with a predominance of tree families Myrtaceae, Meliaceae, Fagaceae, Dipterocarpaceae. 15 V 2016. O. V. Morozova” (LE 315627, fig. 1h).

Table

Boletaceae species in the nature protected areas studied, with voucher and Genbank numbers

Species	Protected areas			Alt. (m)	LE numbers	GenBank numbers	
	Kon Ka Kinh	Kon Chu Rang	Kon Plong			ITS	<i>tefla</i>
<i>Aureoboletus sinobadius</i>	+			1220	LE 312680	MZ451340	MZ424885
<i>Boletellus areolatus</i>	+		+	980 1030	LE 315577 LE 315576	MZ451341 MZ451342	– –
<i>Boletus</i> sp. 1	+			1300	LE 312687	MZ451343	–
<i>Boletus</i> sp. 2	+			1050	LE 312698	MZ451344	–
<i>Chalciporus</i> sp. 1	+			1000	LE 312688	MZ451345	MZ424888
<i>Chalciporus</i> sp. 2		+		1000	LE 312689	MZ451346	MZ424889
<i>Chiuva viridula</i>	+	+		1000	LE 315611 LE 315612	MZ451347 –	MZ424887 –
<i>Crocinoletus rufoaureus</i>			+	1280	LE 315607 LE 315561	– –	– MZ424876 (from Bidoup – Nui Ba NP)
<i>Fistulinella aurantioflava</i>	+			1220	LE 315616	MW784159	–
<i>Hortiboletus rupicapreus</i>	+			1000 1200	LE 312677 LE 312678	MW784161 MW784162	MZ424893 MZ424894
<i>Hourangia nigropunctata</i>	+			1270	LE 315626	MZ451348	–
<i>Ionosporus longipes</i>		+		1000	LE 315589	MZ451349	MZ424890
<i>Neoboletus multipunctatus</i>	+			830 1080 1280	LE 315625 LE 312474 LE 315637	MZ451350 MZ451351 –	– – –
<i>Neoboletus obscureumbrinus</i>	+			1090	LE 315548	MZ451352	MZ424891
<i>Phylloporus luxiensis</i>	+			1020	LE 315622	–	MZ424877
<i>Phylloporus rubiginosus</i>	+			1000	LE 315623	MZ451353	–
<i>Phylloporus</i> sp. 1		+		1000	LE 312684	–	MZ424892
<i>Phylloporus</i> sp. 2			+	1020	LE 312685	MZ451354	–
<i>Porphyrellus nigropurpureus</i>			+	1100	LE 315621	–	MZ424878
<i>Pulveroboletus subrufus</i>	+			1050	LE 312686	MZ451355	MZ424879
<i>Strobilomyces</i> aff. <i>echinocephalus</i>	+			1200	LE 312681	–	MZ424880
<i>Strobilomyces</i> aff. <i>glabriceps</i>	+			1220	LE 312682	–	MZ424881
<i>Strobilomyces seminudus</i>	+			970	LE 315628	MZ451356	–
<i>Tylopilus atripurpureus</i>	+			970	LE 312683	–	MZ424884
<i>Tylopilus atroviolaceobrunneus</i>	+			1000	LE 315627	–	MZ424882
<i>Tylopilus</i> aff. <i>balloui</i> 1	+			1300	LE 312532	MZ451357	MZ424883
<i>Tylopilus</i> aff. <i>balloui</i> 2		+		1000	LE 312700	MZ451358	MZ424886
<i>Tylopilus subotsuensis</i>		+		1000	LE 312527	–	MW014272
Total	20	6	4				
	28						



Fig. 1. Basidiomata *in situ*: a, b – *Strobilomyces* aff. *echinocephalus* (LE 312681); c – *Strobilomyces* aff. *glabriceps* (LE 312682); d, e, f – *Strobilomyces* *seminudus* (LE 315628); g – *Tylopilus* *atripurpureus* (LE 312683); h – *Tylopilus* *atroviolaceobrunneus* (LE 315627); scale bar = 1 cm.

! *Tylophilus* aff. *balloui* [1] (Peck) Singer: “Kon Ka Kinh National Park, 14.21988°N, 108.30936°E, 1300 m a. s. l., on the soil in a tropical mountain polydominant forest with the participation of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 20 V 2016. A. V. Alexandrova” (LE 312532).

! *Tylophilus* aff. *balloui* [2] (Peck) Singer: “Kon Chu Rang Nature Reserve, 14.50516°N, 108.58140°E, 1000 m a. s. l., on soil in middle-mountain evergreen mixed forest. 27 V 2016. A. V. Alexandrova” (LE 312700).

Tylophilus subotsuensis T. H. G. Pham, A. V. Alexandrova et O. V. Morozova: “Kon Chu Rang Nature Reserve, 14.50042°N, 108.56338°E, 1000 m

a. s. l., on soil in middle-mountain evergreen mixed forest. 27 V 2016. A. V. Alexandrova” (LE 312527) (Crous et al., 2020).

Subfamily Leccinoideae G. Wu et Zhu L. Yang

! *Ionosporus longipes* (Masee) Khmeln., Davoodian, Raspé, S. M. L. Lee et Halling: “Kon Chu Rang Nature Reserve, Son Lang Commune, vicinity of waterfalls, 14.51413°N, 108.54630°E, 1000 m a. s. l., on the soil in a middle-mountain evergreen mixed forest with a predominance of Podocarpaceae (*Dacrydium elatum*, *Dacrycarpus imbricatus*), Magnoliaceae, Burseraceae, Myrtaceae. 25 V 2016. O. V. Morozova” (LE 315589, fig. 2a).



Fig. 2. Basidiomata in situ: a – *Ionosporus longipes* (LE 315589); b – *Aureoboletus sinobadius* (LE 312680); c – *Hourangia nigropunctata* (LE 315626); d – *Phylloporus luxiensis* (LE 315622).

Subfamily Xerocomoideae Singer

! *Aureoboletus sinobadius* Ming Zhang et T.H. Li: “Kon Ka Kinh National Park, 14.21226°N, 108.31318°E, 1090 m a. s. l., on the soil in tropical mountain polydominant forests with the participation of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. A. V. Alexandrova” (LE 312680, fig. 2b).

Boletellus areolatus Hirot. Sato: “Kon Ka Kinh National Park, 14.20948°N, 108.31276°E, 980 m a. s. l., on soil in a middle-mountain evergreen broadleaf forest with the participation of families Magnoliaceae, Myrtaceae, Theaceae, Lauraceae, Fagaceae. 16 V 2016. O. V. Morozova” (LE 315577); “Kon Plong Protected Forest, Mang Canh Commune, 5 km north of Kondu Village, 14.72222°N, 108.316°E, 1030 m a. s. l., on soil in a middle-mountain polydominant rainforest, 23 IV 2015. A. V. Alexandrova” (LE 315576).

! *Hourangia nigropunctata* (W.F. Chiu) Xue T. Zhu et Zhu L. Yang: “Kon Ka Kinh National Park, 14.222330°N, 108.310347°E, 1270 m a. s. l., on the soil in a tropical mountain polydominant forest with the participation of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 20 V 2016. A. V. Alexandrova” (LE 315626, fig. 2c).

! *Phylloporus luxiensis* M. Zang: “Kon Ka Kinh National Park, 14.209184°N, 108.314681°E, 1020 m a. s. l., on the soil in a tropical mountain polydominant forest with a predominance of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. A. V. Alexandrova” (LE 315622, fig. 2d).

Phylloporus rubiginosus M. A. Neves et Halling: “Kon Ka Kinh National Park, 14.2187°N, 108.3168°E, 1000 m a. s. l., on the soil in tropical middle-mountain polydominant forest dominated by Lauraceae, Myrtaceae, Meliaceae, Fagaceae, Dipterocarpaceae. 15 V 2016. O. V. Morozova” (LE 315623).

Subfamily Zangoideae G. Wu, Y. C. Li et Zhu L. Yang

Chiua viridula Y.C. Li et Zhu L. Yang: “Kon Ka Kinh National Park, 14.20791°N, 108.31500°E, 995 m a. s. l., on the soil in a middle-mountain middle-mountain polydominant forest with a predominance of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. E. S. Popov” (LE 315611); “Kon Chu Rang Nature Reserve, vicinity of waterfalls, 14.51413°N, 108.54630°E, 1000 m a. s. l., on the soil in a middle-mountain evergreen mixed forest with a predominance of Podocarpaceae (*Dacrydium*

elatum, *Dacrycarpus imbricatus*), Magnoliaceae, Burseraceae (*Canarium*), Myrtaceae (*Syzygium*). 25 V 2016. O. V. Morozova” (LE 315614, fig. 3a, b); *ibid.* “01 VI 2016. O. V. Morozova” (LE 315612).

Pulveroboletus-group

Crocinoletus rufoaureus (Masse) N. K. Zeng, Zhu L. Yang et G. Wu: “Kon Plong Protected Forest, 5 km north of Kondu Village, headwaters of the La and Khe rivers, 14.7455°N, 108.3019°E, 1280 m a. s. l., middle-mountain polydominant forest dominated by Podocarpaceae, Magnoliaceae, Myrtaceae, Calophyllaceae, Elaeocarpaceae, Betulaceae. 05 VI 2016. A. V. Alexandrova” (LE 315607).

! *Neoboletus multipunctatus* N. K. Zeng, H. Chai et S. Jiang: “Kon Ka Kinh National Park, 14.211846°N, 108.313694°E, 1080 m a. s. l., on soil in a tropical mountain polydominant forest with the participation of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. A. V. Alexandrova” (LE 315625, fig. 3c); *ibid.*, “14.21946°N, 108.30940°E, 1280 m a. s. l. 20 V 2016. A. V. Alexandrova” (LE 312474); *ibid.*, “Krong commune, K’bang district, 14.310920°N, 108.438320°E, 830 m a. s. l., on soil in tropical middle-mountain polydominant forest with the participation Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 13 V 2017. A. V. Alexandrova” (LE 315637).

Neoboletus obscureumbrinus (Hongo) N. K. Zeng, H. Chai et Zhi Q. Liang [= *Sutorius obscureumbrinus* (Hongo) G. Wu et Zhu L. Yang]: “Kon Ka Kinh National Park, 14.21226°N, 108.31318°E, 1090 m a. s. l., on the soil in tropical mountain polydominant forests with the participation of representatives of the families Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. A. V. Alexandrova” (LE 315548, fig. 3e, f).

! *Pulveroboletus subrufus* N.K. Zeng et Zhu L. Yang: “Kon Ka Kinh National Park, 14.21052°N, 108.31434°E, 1050 m a. s. l., on the soil in a tropical mountain polydominant forest with the participation of Myrtaceae, Meliaceae, Anacardiaceae, Fagaceae, Theaceae. 16 V 2016. A. V. Alexandrova” (LE 312686, fig. 3d).

Totally, the presence of 28 species of Boletaceae in the studied area were confirmed by the molecular data (Table). *Strobilomyces* aff. *echinocephalus*, *S.* aff. *glabriceps*, and *Tylopilus* aff. *balloui* (two different lines) morphologically are close to known species but genetically not identical with the



Fig. 3. Basidiomata *in situ*: a, b – *Chiua viridula* (LE 315614); c – *Neoboletus multipunctatus* (LE 315625); c – *Pulveroboletus subrufus* (LE 312686); e, f – *Neoboletus obscureumbrinus* (LE 315548).

sequences kept in the NCBI GenBank. In addition, 6 more genotypes were revealed on the base of the molecular study. They could not be attributed to any known species either by molecular or morphological data; there are: *Boletus* sp. 1, *Boletus* sp. 2, *Chalciporus* sp. 1, *Chalciporus* sp. 2, *Phylloporus* sp. 1, *Phylloporus* sp. 2.

The species are distributed between 17 genera belonging to 5 subfamilies and the *Pulveroboletus* group. Among the territories studied, the highest diversity of boletoid species was found in the Kon Ka Kinh National Park due to the higher diversity of the communities represented there and more favorable weather conditions during the collection period. The mountain evergreen broad-leaved and coniferous-deciduous forests of this park are richest in the diversity of the Boletaceae species.

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