Inocybaceae and affiliated taxa from West Africa

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Abstract

Inocybaceae and its affiliated taxa recorded in West Africa were examined by bibliographic survey through available publications coupled with field data collections in Benin, Burkina Faso, Côte d'Ivoire, Guinea, Mali and Togo. Twenty-one Inocybaceae and affiliated taxa have been reported in the region. All taxonomic names have been checked in Index Fungorum and the distribution of *Inocybe beninensis, I. flavipes, I. fuscobrunnea, I. pallidiangulata, Inosperma africanum, I. bulbomarginatum, I. flavobrunneum, Mallocybe africana, Pseudosperma afrofibrosum, P. beninense* and *P. fragilipes* in West Africa were reported. In addition, results of Basic Local Alignment Search Tool search including some undescribed collections from Zambia, such as PC96082, PC 96204 with PC:0088767 and L4512 Inoc Zam05 that showed similarity respectively with the collections of I*nosperma bulbomarginatum, Mallocybe africana and Inocybe flavipes* from West Africa with >97% similarity.

Keywords: Checklist, Ectomycorrhizal fungi, *Inocybe*, Distribution, *Pseudosperma*, West Africa

INTRODUCTION

Inocybaceae Julich, is monophyletic family with a worldwide distribution. It encompasses nearly 1,050 species (Matheny *et al*., 2020) found mainly in forests (from woodland, gallery or dense forests) and rarely in grasslands, wetlands or agricultural lands (Ov, 2015). The species of Inocybaceae are ectomycorrhizal and associate with 23 families of vascular plants (Matheny *et al*., 2020). Recently, Matheny *et al.* (2020) suggested a revised phylogeny for the family Inocybaceae. Today, Inocybaceae contains seven genera, *Auritella* Matheny & Bougher, *Inocybe* (Fr.) Fr., *Inosperma* (Kühner) Matheny & Esteve-Rav., *Mallocybe* (Kuyper) Matheny, Vizzini & Esteve-Rav, *Nothocybe* Matheny & K.P.D. Latha, *Pseudosperma* Matheny & Esteve-Rav and *Tubariomyces* Esteve-Rav. & Matheny (Matheny *et al*., 2020).

However, due to similarity and lack of molecular analyses, a large number of Inocybaceae taxa were classified in Cortinariaceae Singer (Horak, 1978; Singer, 1986, 1975) and probably all that were recognized then, which may include taxa that are not recognized now such as *Astrosporina* Schröt. In the literature, most of the premolecular classifications merged not only Inocybaceae with affiliated taxa, Crepidotaceae Singer and Tubariaceae Vizzini. The first taxonomic evaluation within Inocybaceae was based on morphological and microscopic characters for the distinction of genera earlier (Kuyper, 1986). Beforehand, Jülich (1982) placed *Inocybe* (Fr.) Fr. in Inocybaceae together with the genus *Astrosporina* which is now known to be polyphyletic and nested within *Inocybe* (Matheny, 2005; Matheny *et al*., 2002).

Except some scarce publications (Aïgnon *et al*., 2021a; b; Buyck and Eyssartier, 1999; Matheny and Watling, 2004; Piepenbring *et al*., 2020) taxonomic documentation of the family Inocybaceae from tropical Africa is scant. But, recent mycological sampling in West Africa reported eleven new species to science that some of which like *Inosperma africanum, I. bulbomarginatum, I. flavobrunneum* and *Mallocybe africana* have been published (Aïgnon *et al*., 2021a;b). Though taxonomic works are still progressing, it is of paramount importance to provide a state-of-the-art related to the diversity known in West Africa, in order to establish a reference guide to detect new species.

In this paper, we provide a checklist of known species of Inocybaceae and affiliated taxa from West Africa based on the literature, observation and field data collection between 2013 and 2018.

MATERIALS AND METHODS

Study area

West Africa is defined here to include 15 countries (Benin, Burkina Faso, Côte d'Ivoire, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo). The recently undertaken sampling trips and collection sites in Benin, Burkina Faso, Côte d'Ivoire, Guinea, Mali and Togo are indicated in Figure 1.

Data compilation

The data were assembled from literature related to Inocybaceae from West Africa. All scientific names have been cross-checked against Index Fungorum (IF) and synonymous names have been separated.

Data from literature were coupled with field observations. We made field surveys from 2013 to 2018. Specimens were collected in Benin (Wari Maro forest reserve, Ouémé Supérieur forest reserve, Okpara forest and Toui-Kilibo forest reserve). Additional surveys were carried out in Burkina Faso (Toussianbandougou gallery forest, Dan gallery forest and Niangoloko forest reserve), Mali (Farako forest reserve), Guinea (Kouraouletediene forest reserve, Levari forest, Baroforest reserve, Moussaya forest reserve, Haut Niger National Park, Telaya forest, Tindo forest and Côte d'Ivoire (Kekrekouakoukro forest and Kouadianikro forest). The sampling sites are presented in Figure 1.

DNA extraction, PCR and sequencing

On the recent collection of Inocybaceae from Benin, Burkina Faso, Côte d'Ivoire, Guinea, Mali and Togo, DNA was extracted from dried badisiomata using a QIAGEN® plant mini kit and for the Polymerase chain reaction (PCR) amplification, three nuclear gene regions such as Internal Transcribed Spacer (ITS), portions of the large subunit ribosomal DNA gene (28S) and RNA polymerase II subunit (RPB2), were amplified using the following primers, ITS1F and ITS4 for the ITS region (Gardes and Bruns, 1993; White *et al.*, 1990), LR0R, LR7, LR5 and LR3R for 28S (Cubeta *et al.*, 1991; Rehner and Samuels 1995 Vilgalys and Hester, 1990,) and bRPB2-6F, bRPB2-7.1R for the most variable region of RPB2 (Matheny 2005). PCR products were cleaned and sequenced at Macrogen Inc. (Macrogen Europe B.V., Amsterdam, Netherlands) using the same primers as those used for PCR. All sequences of the new species are deposited on GenBank (Aïgnon *et al.*, 2021a;b) and the new sequences were subjected to a BLAST search (97% similarity) and relevant related sequences retrieved from GenBank.

RESULTS

Inocybaceae and affiliated/Allied taxa in west Africa

Twenty-one Inocybaceae and affiliated taxa have been reported from West Africa. Table 1 summarizes the different species of Inocybaceae as well as the affiliated taxa of West Africa.

Existing data show that Inocybaceae and affiliated taxa have been recorded in four countries from West Africa i.e., Ghana, Nigeria, Senegal and Sierra Leone and collected in forests dominated by *Adenia lobata* Eng, *Afzelia africana* Sm. ex Pers., *Afzelia bella* Harms, *Afzelia bracteata* T. Vogel ex Benth, *Anthonotha crassifolia* Baill. and *Uapaca chevalieri* Beille. But, recent sampling in Benin, Burkina Faso, Côte d'Ivoire, Guinea, Mali and Togo has shown that the species of Inocybaceae are found in the vegetations dominated by *Isoberlinia doka* Craib & Stapf, *I. tomentosa* (Harms) Craib & Stapf, *Uapaca togoensis* Pax, *U. guineensis* Müll. Arg., *Monotes kerstingii* Gilg and *Berlinia grandiflora* Hutch. & Dalziel.

At the 97% threshold, after BLAST searched at NCBI (www.blast.ncbi.nlm.nih.org), *Inocybe* sp. PC96082 from Zambia present high similarity with the collections

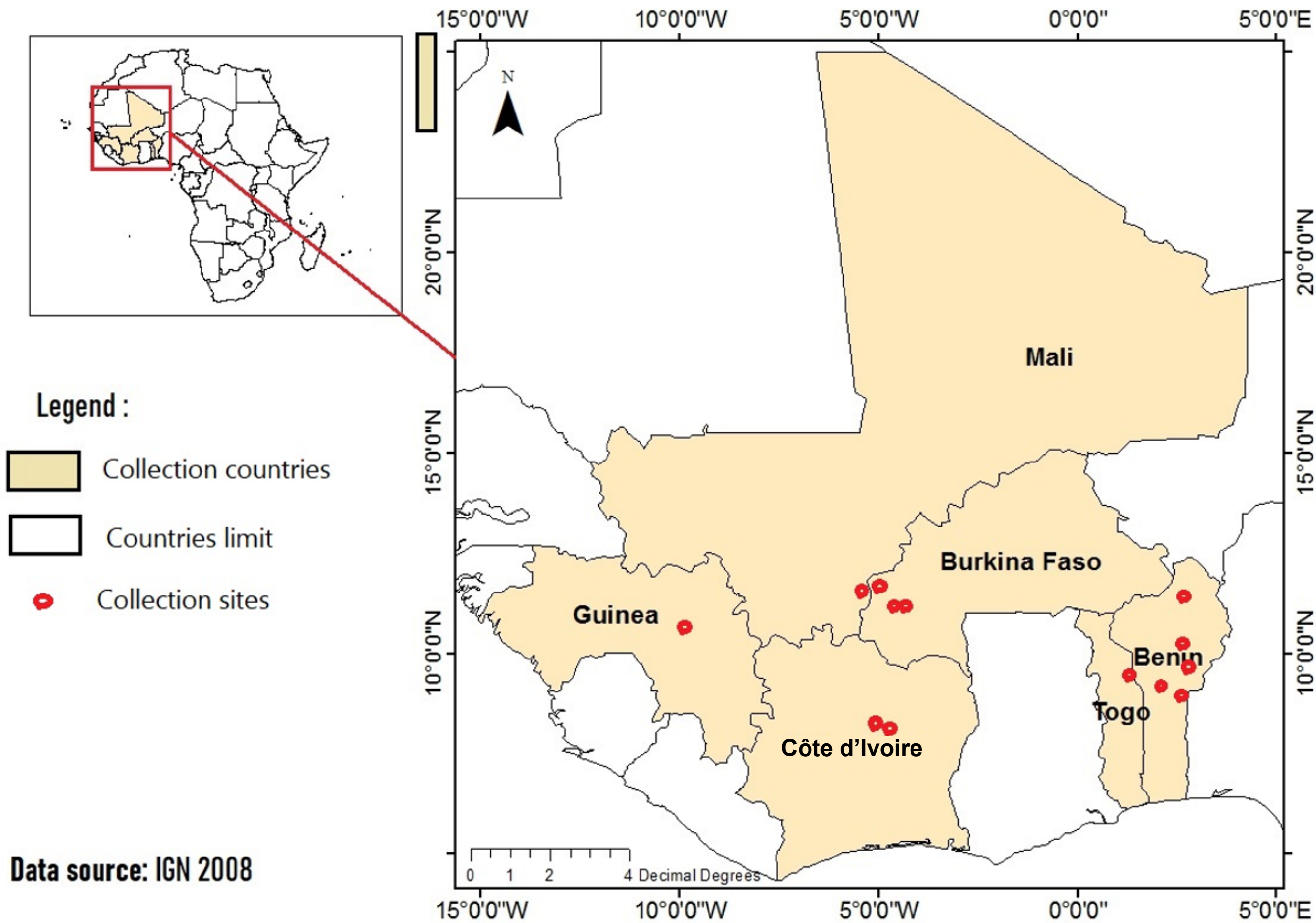

Figure 1: Map of West Africa showing the studied areas and recent sampling sites

of *Inosperma bulbomarginatum*, same for the collections PC 96204 and PC:0088767 from Zambia with the collections of *Mallocybe africana* from West Africa, as well as the collection L4512 Inoc Zam05 from Zambia with the collections of *Inocybe flavipes* from West Africa which appear to be the same species.

DISCUSSION

Uptill now, only five species of Inocybaceae, *Inocybe ghanaensis* (Pegler 1969; Piepenbring *et al.,* 2020), *Mallocybe africana* (Aïgnon *et al.*, 2021b), I*nosperma africanum, I. bulbomarginatum,* and *I. flavobrunneum* (Aïgnon *et al.,* 2021a) are reported and well described from West Africa to our knowledge, but many taxa are still without description and wait to be published *Inocybe beninensis, I. flavipes, I. fuscobrunnea, I. pallidiangulata, Pseudosperma afrofibrosum, P. beninense, P. fragilipes*. However, some name is not validated such as *Inocybe* sp. "gbadjii" registered in index fungorum but it is not consequently described due to lack of diagnosis and type (Boa, 2004). In addition to these species there are many undescribed collections described as *Inocybe* spp. from Burkina-Faso, Guinea, Nigeria and Senegal (Redhead, 1968; Thoen and Ducousso, 1989; Bâ *et al.*, 2012; Piepenbring *et al.*, 2020). Recent findings (Aïgnon *et al.*, 2021a;b) has increased the diversity of Inocybaceae in West Africa to more than eighteen species (Table 1). However, the Central and East Africa regions contain

Table 1: Checklist of Inocybaceae and affiliated taxa from West Africa

Family	Species	Authority	Host Plant	Distribution	Observations	References
Crepidotaceae	*Crepidotus applanatus*	(Pers.) P. Kumm.	*Adenia lobata*	Sierra Leone	Field observation: Collected from dead trunks of *Adenia lobata*	(Beeli, 1938)
	Crepidotus caspari	Velen.	-	Sierra Leone	-	(Holden, 1970)
	Crepidotus mollis	(Schaeff.) Staude	-	Nigeria	Dead decaying wood (Tree stump and fallen logs), Decay trees, Dead decaying wood (Tree stump and fallen logs)	(Beeli, 1938) (Osemwegie and Okhuoya, 2011) (Osemwegie *et al.*, 2006) (Osemwegie *et al.*, 2010)
Inocybaceae	*Inocybe beninensis*	Aïgnon, Yorou & Ryberg	*Isoberlinia doka and I. tomentosa*	Benin	Field observations: on soil	In press
	I. flavipes	Aïgnon, Yorou & Ryberg	*Isoberlinia doka and I. tomentosa*	Benin, Togo	Field observations: on soil	In press
	I. fuscobrunnea	Aïgnon, Yorou & Ryberg	*Berlinia grandiflora*	Burkina Faso, Côte d'Ivoire	Field observations: on soil	In press
	I. ghanaensis	Pegler	-	Ghana	Field observations: on bare soil	(Pegler, 1969) (Holden, 1970)
	I. pallidiangulata	Aïgnon, Yorou & Ryberg	*Berlinia grandiflora*	Burkina Faso, Côte d'Ivoire	Field observations: on soil	In press
	Inocybe sp.		-	Benin	-	(Boa, 2004)
	Inocybe sp.		*Afzelia africana*	Senegal	Field observations: Appeared on lateral roots of *Afzelia africana*	(Bâ *et al.*, 2012)
	Inocybe sp.		*Afzelia bella*	Senegal	Field observation: Appeared near of *Afzelia bella*	(Redhead, 1968)
	Inocybe sp.		*Anthonotha crassifolia, Uapaca chevalieri*	Senegal	Test synthesis mycorrhizae in vitro or in semi-axenic condition	(Thoen and Ducousso, 1989)
	Inocybe sp.		*Afzelia africana*	Senegal	Rootlets fixation in formaldehyde-acetic acid	(Thoen and Bâ, 1989)
	Inocybe sp.		*Afzelia africana*	Senegal	Rootlets fixation in formaldehyde-acetic acid	(Thoen and Bâ, 1989)
	Inosperma africanum	Aïgnon, Yorou & Ryberg	*Isoberlinia doka and Berlina grandiflora.*	Benin, Burkina Faso, Guinea, Côte d'Ivoire, Togo	Field observations: on soil	(Aïgnon *et al.*, 2021a)
	I. bulbomarginatum	Aïgnon, Yorou & Ryberg	*Isoberlinia doka, I. tomentosa*	Benin,	Field observations: on soil	(Aïgnon *et al.*, 2021a)
	I. flavobrunneum	Aïgnon, Yorou & Ryberg	*Isoberlinia doka and I. tomentosa*	Benin,	Field observations: on soil	(Aïgnon *et al.*, 2021a)
	Mallocybe africana	Aïgnon, Yorou & Ryberg	*Isoberlinia doka and I. tomentosa*	Benin, Togo, Burkina Faso, Côte d'Ivoire	Field observations: on soil	(Aïgnon *et al.*, 2021b)
	P. afrofibrosum	Aïgnon, Yorou & Ryberg	*Isoberlina doka*	Benin	Field observations: on soil	In press
	P. beninense	Aïgnon, Yorou & Ryberg	*Isoberlina doka*	Benin	Field observations: on soil	In press
	P. fragilipes	Aïgnon, Yorou & Ryberg	*Isoberlina doka*	Benin	Field observations: on soil	In press

high diversity of Inocybaceae. The diversity of Inocybaceae is also high in the Central and East Africa regions where *Auritella* encompasses three species such as *Auritella hispida* Matheny & T.W. Henkel, *Auritella spiculosa* Matheny & T.W. Henkel and *Auritella aureoplumosa* (Watling) Matheny & Bougher from Cameroon, as well as two undescribed species *Inocybe* sp. TU112047 and *Inocybe* sp. TU112061 from Gabon (Matheny *et al.*, 2017, 2012). In *Tubariomyces*, there is an undescribed species *Tubariomyces* sp. 2 BB6018 (PC), from Zambia (Vizzini *et al.*, 2013). *Inosperma misakaense* (Matheny & Watling) Matheny & Esteve-Rav. is known from Zambia (Aïgnon *et al.*, 2021; Buyck and Eyssartier, 1999; Gardens, 2017; Matheny and Watling, 2004). As well as, there are several undescribed species from Zambia including *Inocybe* sp. PC 96042, *Inocybe* sp. PC 96039, *Inocybe* sp. PC 96081, *Inocybe* sp. PC 96095, *Inocybe* sp. PC 96204, *Inocybe* sp. PC 96111, *Inocybe* sp. PC 96013, *Inocybe* sp. PC 96083, *Inocybe* sp. BB3233, *Inocybe* sp. BB6018 and *Inocybe* sp. PC 96073 (Matheny *et al.*, 2009).

Ectomycorrhizal symbiosis is proven between some species of Inocybaceae and the roots of native trees. For example, *Anthonotha crassifolia* and *Uapaca chevalieri* are partner trees of some unidentified Inocybaceae species in the semi-deciduous forest of Senegal (Thoen and Ducousso, 1989), likewise for *Afzelia bella* in the tropical forest of Nigeria (Redhead, 1968) and also *Afzelia africana* in wooded areas and gallery forest in Senegal (Thoen and Bâ, 1989). In addition, these ectomycorrhizal host trees are found in various vegetations such as Zambesian and Sudanian woodlands, semi-deciduous forests, Guineo-Congolean dense forests and gallery forests. The presence of Inocybaceae species in these vegetations is remarkable, and there is little doubt that other African species of *Afzelia, Anthonatha* and *Uapaca* are also ectomycorrhizal associated with *Inocybe* but it is difficult to confirm without consequent analysis.

Analysis of the recent collections (Aïgnon *et al.*, 2021a,b) have shown a wide distribution of Inocybaceae species in vegetations dominated by *Uapaca* spp., *Isoberlinia* spp. and *Berlinia grandiflora* with large distributed in Benin, Burkina Faso, Guinea, Senegal and Togo (Thoen and Ducousso, 1989; Moyersoen and Fitter, 1999; Newbery and Stoll, 2013). The same is true for *Monotes kerstingii* often mixed with stands of *Isoberlinia* spp. (Sanon *et al.*, 1997). It is then clear that Inocybaceae have not been sufficiently evaluated in West Africa and so there is need to study the biology and distribution of these species to determine specific host trees for conservation interventions.

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