Promoting teaching and research on African fungi by field schools on tropical mycology in Benin

Meike Piepenbring[1] and Nourou S. Yorou[2]

[1]Department of Mycology, University Frankfurt am Main, Biologicum, Max-von-Laue-Str. 13, 60438 Frankfurt am Main, Germany; Corresponding author email: piepenbring@bio.uni-frankfurt.de

[2]Faculty of Agronomy, University of Parakou, BP 123, Parakou, Benin

Abstract: In 2015, 2016, and 2017, three international field schools on tropical mycology were realized in Benin by the University of Parakou, Benin, in collaboration with the University of Frankfurt, Germany. A total of 69 participants from 14 countries of tropical Africa and three different countries of Europe included 61 student participants from Africa and Germany as well as eight African and international teachers. By demonstrations and collecting fungi in the field, light microscopic analysis of the specimens collected, literature analysis, checklist work, and seminars, knowledge on fungal diversity, systematics, morphology, and ecology was shared and generated. Through joint field and laboratory activities, participants were motivated to pursue studies in mycology in order to contribute not only to general knowledge on tropical fungi, but also promote sustainable management of fungi in forestry, agriculture, and the environment, as well as to use fungi for food, medicine, and other applications.

Key words: Africa, capacity building, checklist of West African fungi, conservation, fungi, mycology.

INTRODUCTION

The African continent harbours hotspots of biodiversity that promise fascinating insights into organismic diversity, interactions, and ecology as well as the presence of organisms useful or harmful to human beings. African animals and plants attracted attention since several centuries, investigation of fungi, however, is still in a pioneer phase in most African countries. This is evident in particular by a lack of checklists and mycological collections of dry fungal specimens or living cultures. Further challenges are the lack of experts and mentors for teaching mycology in Africa, students interested in fungi, and funds to realize projects (Gryzenhout *et al.* 2012). Meanwhile, fungal diversity is threatened by land allocation, habitat destruction, high population density causing intensive land use, bush fire, and climate change (Yorou & De Kesel 2011).

Fig. 1. The group of field school participants at Koussoucoingou in northern Benin in 2017.

MATERIALS AND METHODS

In order to promote mycological teaching and research in tropical Africa, three international field schools in Benin were organized by the Faculty of Agronomy, University of Parakou (Benin) in collaboration with the Department of Mycology and the Centre for Interdisciplinary African Studies (ZIAF) both located at the University of Frankfurt am Main, Germany. Each field school lasted approximately three weeks during rainy seasons 2015, 2016, and 2017. Financial support was provided mainly by the Volkswagen Foundation.

Participants

The number of participants of each Field School was between 25 and 35 (Fig. 1). Most originated from tropical African countries and were selected based on experience in mycology, being in the process of academic promotion by research on fungi, high motivation to investigate fungi, representing the diversity of African countries, and gender balance. For long-term mycological research and local teaching, it is important that the trained persons are permanently affiliated to their home institution. In total, 49 promising young mycologists from 14 African countries participated in the three field schools, namely from Benin, Burkina Faso, Cameroon, Congo Republic, Democratic Republic of Congo, Ethiopia, Ghana, Guinea, Ivory Coast, Mali, Niger, Nigeria, Senegal, and Togo, complemented by 12 students from the University of Frankfurt. Professional mycological and botanical knowledge was provided by three teachers from Africa, four teachers from Germany, and one international expert mycologist.

Fig. 2. Field school participants in Okpara forest with ectomycorrhizal fungi presented by Nourou S. Yorou.

Fig. 3. Parasitic fungi on cultivated plants presented by Meike Piepenbring. Photo Marina Hiemann.

Field forays with demonstrations

The field school groups travelled to different types of natural vegetation (savannah, different types of forest, inselbergs), fields with cultivated plants, pastures, swamps, rural vegetation, and botanical gardens, where participants looked for any fungi (including lichens) in any ecological niche (on soil, dead wood, living plants, and dead insects and other animals). In the field, teachers presented the fungi and plants to the group, providing names if possible as well as information on ecology, interactions with other organisms, distinctive morphological characteristics, and systematic relationships (Figs 2–3). Photos of fungi *in situ* and fresh specimens were taken together with notes on information provided and directly observed in the field (substrates, GPS data). Selected specimens were collected for further analysis in the laboratory.

Light microscopic analysis of fresh specimens

Fresh specimens obtained in the fieldwork (Fig. 4) were investigated the same day or one day afterwards by light microscopy for the analysis of distinctive microscopic characteristics. Participants made drawings of macromorphological and cellular structures and took measurements of spores as well as other structures (Fig. 5). Textbooks (e.g. Piepenbring 2015; Fig. 7), monographs, pdf files, databases, the preliminary checklist (*see below*), and knowledge of the participants allowed a preliminary identification of specimens to levels of order, genus, or species. For the evening, each participant (or groups of participants) selected one fungal specimen to work on and presented information on the systematic, taxonomic, and morphological characteristics of that species to class mates (Fig. 6; *cfr*. Oberwinkler 2012). These presentations were complemented by basic mycological teaching information.

Seminars and further talks

Participants presented their ongoing mycological investigation for MSc or PhD degrees to the group by seminar talks. Further presentations referred to specific mycological subjects, excursion sites (e.g. inselbergs), or checklist work. By general mycological talks presented to the university public, professors and students from other fields became aware of the mycological activities and learnt about fungi.

Fig. 4. Participants collecting basidiomes of *Scleroderma dictyosporum* in Benin.

Fig. 5. Light microscopic analysis of collected fungi at Taneka in Benin.

Fig. 6. Report on observations on studied specimen by students.

Fig. 7. Presentation of certificate and textbook on tropical mycology at the University of Parakou.

Subject foci of the field schools

Within the framework of general mycological teaching and research on fungal ecology and diversity, ectomycorrhizal fungi as well as plant parasitic microfungi on cultivated and wild plants were the focus of interest. In the field and in the laboratory, the identification of plants was also important, in particular for mycorrhizal forest trees and hosts of plant parasitic fungi. Further important subjects were ethnomycology in African rural societies, *Termitomyces* spp. and fungal gardens of termites, as well as the diversity and ecology of lichens and fungus-like organisms (*Myxogastria*).

Checklist work

Records of fungal species available from primary and secondary scientific literature for different countries of West Africa were compiled, as for the checklist provided by Piepenbring (2006, 2007; http://biogeodb.stri.si.edu/fungi/) for fungal species known from Panama. The following pieces of information were compiled for each species record in an excel sheet:

- scientific name of the fungal species with author(s) (only names valid according to Index Fungorum);
- the systematic position of the species;
- life form;
- substrate or host plant with host family;
- literature reference with page number, eventually followed by synonym used in the publication; and
- geographical subregion (i.e. the respective country of West Africa).

Such a checklist is useful to obtain species knowledge, to learn about sizes of different groups of fungi as well as their contributions to overall fungal diversity, and to learn about the history of mycological activities in the area of interest. A checklist is also helpful in the identification of fungal specimens, because it indicates which species are known to occur in the area and may provide references to literature available to identify the species known in the area. A (close to) complete checklist is indispensable to decide that a collected specimen represents a record new for the area or subregion, it helps to identify under-collected groups as well as under-collected geographical areas, and also provides numbers for publications and political issues.

Based on the number of plant species known for the area of interest and the "Hawksworth factor" of approx. 6 (maybe 8) species of fungi in an area per species of plant found there (Hawksworth 2001, Hawksworth & Lücking 2017), an estimated number of fungal species existing in the area can be calculated and compared to the species number reached in the checklist compilation. The gap between the diversity evident by the checklist and the estimated fungal species diversity provides an argument for nature conservation and mycological research proposals.

RESULTS AND DISCUSSION

The activities described here yielded numerous short-term results. All participants learnt from nature, from teachers, and from each other on fungal diversity, morphology, and ecology, as well as on plant diversity associated with fungi. Student participants profited for their theses by additional mycological knowledge, practice in seminar presentation, discussions, and motivation. Some participants collected specimens for their ongoing research for theses. Participants learnt to make anatomical illustrations, measure cellular structures, describe species, and search and analyse literature for species identification. By these activities, several new records of fungi for Benin were identified, mainly common, well-known species or species for which monographs are available. By activities in the field and work on fresh fungal specimens, original, high quality teaching material, particularly numerous photographs of fungi in nature and some videos of moving elements, were obtained. Last but not least, interactions in the group contributed to increased intercultural competences of all participants and to networking among African mycologists.

Long-term goals and results expected in the future include further projects for research on fungi and teaching mycology, an increasing number of African mycologists and students who are planning to make a scientific career in mycology, and contributions to the knowledge of fungal diversity in Africa. Increased knowledge and awareness will promote sustainable use and management of fungi in forestry, agriculture, and the environment, as well as fungi for food, medicine, and other applications.

With these goals in mind, numerous challenges have to be accepted, such as

limited equipment and laboratory space, simple living conditions, unpredictable weather conditions, often interrupted electric power supply, high costs of internet connection, and limited access to scientific literature. For further challenges and the sources of motivation necessary to cope with them see Piepenbring *et al.* (2018).

ACKNOWLEDGEMENTS

We are thankful to Ralph Mangelsdorff, Brice Sinsin, Marco Schmidt, Ludwig Beenken, and Marcin Piatek who collaborated as teachers, to Karen Hahn, Carola Glatthorn, Gérard Laourou, and other students from the research unit for Tropical Mycology, University of Parakou, for helping in the organisation of the activities, and Marina Hiemann for photos. Institutional support was provided by the University of Parakou, the University d'Abomey Calavi, and the Centre for Interdisciplinary African Studies (ZIAF) of the University of Frankfurt am Main, Germany. The three field schools were made possible by funding obtained from the Volkswagen Foundation, with complementary support by the Association of Friends and Supporters of the University of Frankfurt as well as the Foundation for the Promotion of International Scientific Relationships of the Johann Wolfgang Goethe-University Frankfurt.

REFERENCES

Gryzenhout M, Jefwa JM, Yorou NS (2012) The status of mycology in Africa: a document to promote awareness. *IMA Fungus* **3**: 99–102.

Hawksworth DL (2001) The magnitude of fungal diversity: the 1.5 million species estimate revisited. *Mycological Research* **105**: 1422–1432.

Hawksworth DL, Lücking R (2017) Fungal diversity revisited: 2.2 to 3.8 million species. *Microbiology Spectrum* **5**(4): FUNK-0052-2016.

Oberwinkler F (2012) Mykologie am Lehrstuhl Spezielle Botanik und Mykologie der Universität Tübingen, 1974–2011. *Andrias* **19**: 23–110.

Piepenbring M (2006) Checklist of fungi in Panama. *Puente Biológico (Revista Científica de la Universidad Autónoma de Chiriquí)* **1**: 1–190.

Piepenbring M (2007) Inventoring the fungi of Panama. *Biodiversity and Conservation* **16**: 73–84.

Piepenbring M (2015) *Introduction to Mycology in the Tropics / Introducción a la Micología en los Trópicos.* St Paul, MN: American Phytopathological Society Press.

Piepenbring M, Lotz-Winter H, Hofmann TA (2018) Incentives and challenges for mycologists in the tropics. *Biosystematics and Ecology Series* **34**: 481–514.

Yorou NS, De Kesel A (2011) Larger fungi. In: *Nature Conservation in West Africa: Red List for Benin* (Neuenschwander P, Sinsin B, Goergen G, eds): 47–60. Ibadan: International Institute of Tropical Agriculture.