Biodiversity and conservation in Cameroon

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Received 18 February 2010 / Accepted 8 September 2010

Abstract. Fungal conservation started attracting the attention of mycologists when the decrease of certain groups of macrofungi became prominent in some countries in the 1980s. Today accurate information on habitat types, substrates, and host specificity of species especially in a semi-quantitative form, are most needed. There is need to pay special attention to experimental studies on the impact of man's influence on the ecosystems and consequently on the mycoflora. Good legislation on threatened species and communities exists in Cameroon. However, there are no evaluation on the conservation studies of Cameroonian fungi, no comprehensive threat assessment for fungi, no culture collection and maintenance centres and no national organ to promote fungal protection and conservation. Poor public perception and knowledge of fungal diversity, lack of personnel, and public and stakeholder education and training should also be given priority.

Key words: Biofertilizer, biopesticide, biodiversity, Cameroon, conservation, ecological threats, fungal conservation, fungal diversity

Introduction

Fungal conservation started attracting the attention of mycologists in the early 1980s when reports began appearing about the prominent decrease of certain groups of macrofungi in some countries (Arnolds 1988; Fellner 1993). It is now evident that, to monitor such changes, there is a great need for accurate quantitative and qualitative information on the ranges of habitat types, substrata, and host specificity of species. Experimental studies on the impact of anthropogenic factors on fungal populations are needed, including the threats of air pollution and urban development, as these impacts may affect management of different types of forest and grassland.

The declining number of fungal taxonomists worldwide is worrying, particularly since more than 90 % of the world's fungi are thought still to remain undiscovered and more than 90 % of those already described are too poorly documented to know if they are endangered or not. The increasing shortfall of mycological expertise is most acutely felt in the world's poorest countries, most being in Africa. Cameroon is no exception.

This is an attempt to describe the current state of fungal conservation in Cameroon. As a nation, Cameroon is conscious of its biological wealth and is trying to fulfil the various processes and directives needed to implement the Convention on Biological Diversity [**CBD**], and to manage the country's biological resources in a sustainable way. To meet the biological resources requirement of Cameroon's growing population, care is taken to maintain the country's relationship with the CBD organs. They also contribute to the valorisation of indigenous knowledge and create organized and acceptable systems of access to genetic resources and benefit-sharing. International cooperation and signing of the Cartagena Protocol to the CBD allows Cameroon to benefit from funding to adopt National Biodiversity control measures, notably biosafety norms and the use of advances in

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modern biotechnology. Currently, the country is evaluating the synergies and capacities for implementing the three conventions related to the environment, namely the CBD, the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD).

National biodiversity

Cameroon is endowed with a rich and abundant biodiversity as a result of its geographical position and climatic variations. The rich volcanic soils in most of the South West and Littoral regions and the influence of the sea have given rise to luxuriant vegetation, and encourage considerable agricultural, forestry and fishing activities. There is thus a high degree of diversity of ecosystems and genetic resources that all relate to the character of the environment, with corresponding effects on human and animal life and the national economy.

Although species inventories have not yet been carried out, data from specific target studies indicate that Cameroon's biodiversity is characterised by abundance, a high degree of endemism and great diversity. These positive attributes are, however, understudied, over-exploited and hence highly threatened. Exploration and research are providing new information about habitats, ecosystems, species, breeds and varieties. Ethno-botanical studies, and analysis of plant communities have shown the need to intensify work on Cameroon biodiversity, but to date fungi remain overlooked.

Table 1. Habitat classification and location in Cameroon (NBSAP Cameroon 2009)

No.	Major Group	Habitat Type	Corresponding Ecosystem	Location in Cameroon
1	Aquatic	Marine water, brackish water, Fresh water: lakes, rivers, artificial ponds, swamps	Marine and coastal, Fresh water	South West Province, Southern and Littoral
2	Forest and Savanna	Natural forest, artificial forests, agriculture lands, Savanna Desert	Tropical humid forest Artificial forests Artificial forests	Adamawa, South, North West, Western provinces
3	Montane	Mountain forests Highland forests, rocks	Montane Woodland savanna	South West province, North West province, Adamawa
4	Soils	Forest soils, agricultural soils Marine soils, lake soils, savannah soils Desert soils Mountain/volcanic soils	All ecosystems	All provinces

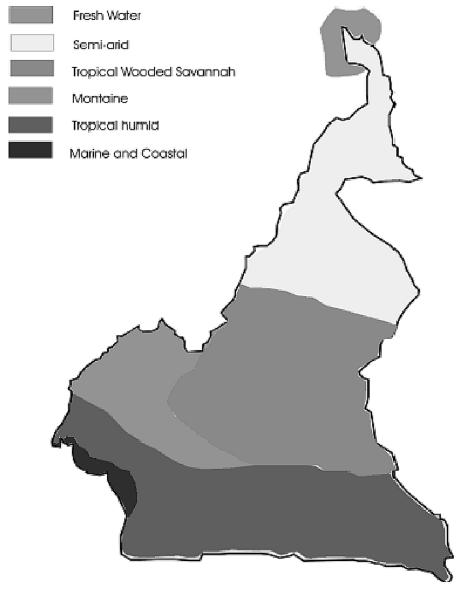

Fig. 1. Map of main ecosystems of Cameroon (MINEF 1998)

Most African ecosystems (92%) are represented in Cameroon, hence the common reference to Cameroon as 'Africa in miniature'. Cameroon has been reported as rich in animal and plant diversity (UNEP/MINEF 1998; MINEP 2009). In plant biodiversity, Cameroon is second in Central Africa, and fourth in Africa as a whole, while ranking fifth in animal diversity in Africa. The country contains 84% of known African primate species, 68% of African passerine birds, 66% of African butterflies (MINEP 2009), and 9050 plant species (Onana 2008), of which 160 are endemic (WCMC 1994). The diversities of most of the country's other taxonomic groups have, however, not been properly assessed.

Six mega-ecosystems (Table 1) contain mosaic layers of biodiversity. Many of the habitats, particularly dense tropical forest ecosystems such as the Korup National Park and the Dja Reserve forest, are still pristine. The Dja Reserve forest has been reported to contain the oldest tropical rain forest in the world, with some organisms reported to have first appeared about 60 million years ago (UNEP 1995). This makes the Guinea-Congolean Rainforest an important focal point for conservation in Africa (WWF 2006).

Major threats to biodiversity components

Most Cameroonians depend directly on biological resources for their livelihood especially as the economy is based on agriculture. Many species are threatened, and the threats increase greatly as demand for products from those biological resources increases. The major threats to biodiversity in Cameroon therefore result from direct and indirect activities of man. Direct activities include agriculture, logging, destruction of vegetation, industrial mining, road construction, urbanization and pollution. The major indirect cause is climate change, which is leading to an increase in temperature, desertification, drought, floods, erosion, and landslides.

Many ecosystems are facing the challenge of invasive alien species. Animal and plant invasives are found in pastures, mangrove swamps, fresh water, farmlands and even the air (Bokwe 2007; Cheek 2004; Howard *et al.* 2003). The intensity of their invasiveness is not known and no attention has yet been paid to identification of ports of entry, methods of prevention, introduction, management, control and eradication.

Nwaga (2007) examined some common bacterial, fungal and viral crop pests and invasives (Table 2), but this list is very incomplete as most crops cultivated in Cameroon, including cereals, are not covered. Most fungi listed are cosmopolitan and very common. Some act in a synergistic manner in causing crop disease and some of these interactions have been demonstrated (Ngala 1987, 2004; Ngala & Adeniji 2003a, b, 2004). One classical example of synergy is the banana/plantain infection by *Fusarium* (*moniliforme*) *verticilloides* and the nematode *Radopholus similis* (Turner & Rosales 2003).

The factors that account for ecosystem degradation also account for habitat loss. Habitat losses have in many cases affected the status of various forms of biodiversity. In a study of the level of wildlife habitat loss in forest ecosystems of five African countries, a 59 % loss was reported for Cameroon. This is the second largest in Africa, and compares with a loss of 39 % for Angola, 56 % for the Central African Republic, 76 % for Chad and 49 % for Congo (MINEP 2009).

Table 2. Some major common invasive crop pests and diseases in Cameroon (MINEP 2009)

Name	Scientific name	Symptoms or damages
Striga (PI)	*Striga* sp.	Sorghum, cowpea are the main hosts
Fusarium disease	*Fusarium oxysporum*	Oil palm hearth (30-50 % incidence)
Black pod disease of cocoa	*Phytophtora megakarya*	Reduced cocoa yield (50-70 %), chemical controls have failed
Cocoyam root rot disease	*Pythium myriotylum*	Tuber yield reduction from 50-70 %
Coffee berry disease	*Colletotrichum coffeanum*	More severe on *Arabica coffee*
Leaf spot	*Mycosphaerella* sp.	Banana/plantain
Aspergillosis	*Aspergillus flavus*	Chicken nanism, cancer in humans from groundnuts or maize feeds
Anthracnose disease, Egussi	*Colletotrichum lagenarium*	Diseases incidence may reach 100 %
Cercospora disease, grapes	*Phaeoramularia angolensis*	Fruits and leaf diseases
Late blight of Irish potato	*Phytophthora infestans*	May cause severe losses on tubers
Leaf blight of cowpea	*Ascochyta phaseolorum*	Defoliation and pod spots causing 30-100 % losses on cowpea
Flat pod disease of groundnuts	*Pythium myriotylum*	May cause empty pod of groundnut in humid forest zones
Bacterial wilt	*Ralstonia solanacearum*	Tomato and Solanaceae wilts
Tuber rot of cassava	*Xanthomonas manihotis*	More severe in humid forest zones
Rosette disease of groundnut	Groundnut Common Rosette Virus	Groundnut stunting, mosaic, reduced growth and yield
Cassava mosaic disease	African cassava mosaic virus	Leaf growth reduction, distortion, yellowing
Mosaic disease of cowpea	Cowpea aphid-borne mosaic virus	Leaf distortion, mosaic, yellowing
Mosaic disease of cowpea and bean	Bean Common Mosaic Virus	Leaf distortion, mosaic, yellowing
Root rot of banana/plantain (Nematode + fungus)	*Radopholus similes* + *Fusarium*	Root destruction and severe plant growth reduction
Root-knot nematodes of vegetables	*Meloidogyne* spp.	Wilting, yellowing, and stunting of tomatoes, peppers and egg plants

About 70 % of the rural population in Cameroon depend on agriculture, and that dependency impacts severely on habitat loss (Table 3). Forest clearing for plantations and peasant agriculture account for about 30–40 % loss of forest cover, while air, soil and water pollution accounts for about 60 % habitat loss. Depending on the ecological zone, agriculture and cattle grazing also contributes significantly to biodiversity loss. Fuel wood harvesting constitutes a great threat to biodiversity conservation in the Savannah and Sahel Regions. Logging also has a large impact. Studies undertaken in selected African countries including Cameroon, showed that damage to residual trees in conventional logging is excessive and can range from 33–70 % in areas with high logging intensity (Nicholson 1958). Even with careful felling, Weidelt (1996) recorded about 200 m^3 of forest area damaged by the felling of one tree.

Other important factors also threaten biodiversity in Cameroon. Cameroon's northern border is partly influenced by the rapid southward advance of the Sahara Desert. In 1998, the country initiated a programme to combat the advancing desert and its influence on biodiversity loss (MINEP 2009). Climate change is manifested in Cameroon (MINEP 2009) through rising sea levels causing disasters in coastal towns, heavier rainfall in coastal and forest ecosystems, floods in all ecosystems, droughts in Sahel Savannah, erosion and landslides in all ecosystems, impacts on vegetative adaptability, extinctions and successions, and rainfall patterns which have changed drastically to the detriment of farming communities. Carbon dioxide emissions for Cameroon in 1995 were estimated to be 4,144,000 metric tons (WRI 1998). In adapting to the impact of climate change, the human population in most of the country's ecosystems is exercising increased pressure on the biological resources within those ecosystems.

Biodiversity conservation efforts

Despite the great contribution of biological resources to the sustainable livelihoods of the Cameroonian population and to national income as a whole, the importance of conservation is not yet widely perceived or understood. There is therefore a great need for constant and continued communication, education, information and creation of awareness notably amongst the public and policy makers.

The government is aware of the loss of habitat in all ecosystems. The policy and legal measures adopted are centered on conservation of species and recovery of lost and degraded sites as set out in the National Biodiversity Strategies and Action Plan [**NBSAP**]. National measures towards habitat recovery include policy development, legislation, forest regeneration, the modernising of agricultural practices, the creation, recovery and management of protected areas, regional co-operation, and programmes and activities geared towards biological resource conservation (Table 4). The government has adopted specific policies and laws for managing biological resources in a sustainable manner. However, despite the abundance of legislation and regulations within the environmental fields, implementation is weak.

In the domain of wildlife conservation, Cameroon has endeavoured to protect over 3,482,741 ha of habitats in 2008 under national parks, forest reserves, sanctuaries, and botanical and zoological gardens (Tables 5–6). The total area under protection is 11 % of the national territory (Table 7). If the 18 % of land designated as Safari hunting zones is regarded as "protected", the figure of national areas under protection is 30 %. However, the actual state of every protected area needs to be reviewed.

Table 3. Rate of plant biomass loss in Cameroon in 2000 (MINEP 2009)

Vegetation type	Land area km^2	Biomass reduction activity	% Loss
Tropical moist forest with short dry season	42 525	Annual perennial agriculture	52
		Timber exploitation	13
		Fuel wood collection	25
		Urbanisation	5
		Decomposition of stumps and branches	5
Tropical moist forest with long dry season	148 180	Annual perennial agriculture	40
		Timber exploitation	2
		Fuel wood collection	20
		Grazing by cattle	15
		Wild fires	15
		On site decomposition	3
		Urbanisation	5
Tropical dry vegetation	49 428	Agriculture	3
		Fuel wood collection	5
		Grazing by cattle	40
		Wild fires	20
Montane forest	1 500	Agriculture	60
		Fuel wood	25
		Grazing	5
		Wild fires	10

Through international co-operation, Cameroon has adopted some practical measures to improve and protect biodiversity-rich areas (Table 7). Implementation of most conventions is done through projects with the technical and financial assistance of international Non Governmental Organizations [**NGO**s] operating in Cameroon to help recover threatened habitats.

Fungal biodiversity: a new arena

Two case studies of fungi from Cameroon indicate that fungal diversity is high and likely to include many new species. In the Mbalmayo Forest Reserve 271 distinct species of fungi belonging to 110 genera in 58 families have been recorded (Douanla-Meli 2007). These were all previously unrecorded from reserve, while 75 of those described were new to Cameroon and 11 were new to science. In a different study, also from Mbalmayo, 140 basidiomycete species were listed. These included 11 gasteromycetes species, 10 *Heterobasidiomycetes,* 9 clavarioid fungi, 19 steroid fungi, 10 lentinoid fungi, 6 ganodermoid fungi, 14 *Hymenochaetaceae* and 61 *Polyporaceae*. In the Tropenbos Campo Program area, more than 125 species of ectomycorrhizal fungi were identified (Onguene, 2000). One fungal species (yet to be identified) was commonly found in association with *Gnetum.* Among ectomycorrhizal fungi, the *Amanitaceae, Russulaceae, Boletaceae* and *Cantharellaceae* were well represented, whereas only a few species of *Cortinariaceae, Sclerodermataceae, Gomphaceae, Clavulinaceae,* and *Hymenochaetaceae* were observed. The same ectomycorrhizal fungi (and trees) also occur in Korup National Park, Cameroon, even though soils and climate are different between Korup and the forests of the TCP area (MINEP 2009).

The soil is a very important reservoir of species diversity for Cameroon. With an economy based on agriculture, fungi, and chromistan and protozoan fungal analogues are highly important, particularly with regard to soil fertility and plant pathology. The main fungal groups reported (Nwaga & Ngonkeu 1998) are *Basidiomycotina* (mycorrhizas, edible, e.g. *Boletus*), *Glomeromycotina* (mycorrhizas, biofertilizers, 45 known species), *Deuteromycotina* (pathogens, agents of biological control, organisms for food technology such as *Trichoderma*), *Mastigomycotina* (pathogens, saprobes), *Phytophthora* (causing black pod disease in cocoa and late blight of potato), *Ascomycotina* (*Saccharomyces* used in beer and alcohol manufacture) and lichens (101 species identified).

Table 4. National measures for habitat recovery (MINEP 2009)

Practical measures	Actual user practices	Habitat location
Policy and legislations	Forestry, Fishery, wildlife policies and laws on conservation of biodiversity New forestry legislation adopt the 'ufa' system where exploited forest is guaranteed management	In all aquatic and terrestrial habitats In the tropical humid dense forest ecosystem habitats
Forest regeneration	ANAFOR ensures regeneration and management Private forest plantations	Mostly in the tropical woodland savanna ecosystem
Agricultural practices	Agro-industrial establishments habitually renew crop habitats though replanting, combating pests and diseases and the use of fertilizers to improve habitat conditions	Plantations of CDC, HEVECAM, PAMOL, SODECOTTON, SODERIX
Creation of protected areas in compensation of lost areas	About 11% of national territory is under P.A. management – Forest reserves, National Parks, Animal Sanctuaries	In tropical humid forest Tropical woodland savanna Fresh water ecosystem
Sub-regional cooperation	CEMAC countries signed the 'Yaounde Declaration' on the conservation of the Tropical forest of the Congo Basin Chad Basin Commission	In tropical humid forest Tropical woodland savanna Fresh water ecosystem
Sacred forests	Creation and maintenance of sacred forests: For cultural practices For traditional practices	Nation wide Traditional healers
Monitoring and evaluation	Setting up of National Observatory for Climate Change (President Biya's proposal and appeal to the UN General Assembly 2008) Creation of Sub Department of Monitoring MINEP	Found on diplomatic and policy statements MINEP planning
Communication, education and public awareness	Most of the activities in forestry, wildlife, agriculture and environment have been subjects of regular radio and television programmes	Information is diffused nationwide
International agreements	Government endeavours to be party to the international agreements related to biodiversity - CBD	CBD, UNFCCC, UNCLOS, UNCCD, Ramsar and others

UNCLOS = United Nations Convention on the Law of the Sea

UNCCD = United Nations Convention to Combat Desertification

Nwaga *et al.* (1998) found that microbial biomes are highest in the primary forests when they studied the impact of land use systems on microbial biomass and endomycorrhizal diversity in humid forests in South Cameroon. *Glomus* spores were most abundant followed by *Gigaspora* spores. Ngala (1987) reported the isolation of several fungi from rice farms in Cameroon and Nigeria as partly contributing to this diversity, and also showed the importance of biological studies on these fungi (Ngala 1989; Ngala & Adeniji 1989).

Nwaga & Ngonkeu (1998) stated that microbes and microscopic fungi are potentially important groups unexploited in Cameroon that can be useful to produce many products such as beverages, food, proteins, solvents, bio-fertilizers, bio-pesticides and minerals. Ngala (2005) showed the importance of biopesticide science and the production and applications of biopesticides in agriculture and health (human and veterinary) in Cameroon. Through the correct use of fungi, it is possible to produce a variety of products useful for domestic purposes and improvement of the economy. This is evidenced by the use of mycorrhizal fungi as biofertilizers.

Conclusions

Legislation exists in Cameroon to protect on threatened animal and plant species and communities, but fungi are rarely mentioned. Very little is known about Cameroonian fungi, and more surveys are needed. To date, no efforts have been made to evaluate the conservation status of Cameroonian fungi. There is no fungal checklist, let alone any fungal red list for the country. These need to be produced for conservation work on fungi in Cameroon to progress. Funding is needed for that.

Threats to fungi are predictable in a general sense, given the probable abundance of the fungal biota and the widespread ecosystem degradation. No threat assessments for fungi have been done in Cameroon. There are no fungal culture collections and no dried reference collections for fungal specimens in Cameroon. As a result, no fungi are held within the country for verification and continued studies. There are also no fungal mapping programmes and no computerized databases to store records of fungi from Cameroon. These would be necessary to provide information, training and input into conservation policy development. They would also constitute a vital baseline for measuring environmental impacts.

Table 5. Evolution of Protected Areas 1996–2008 (MINEP 2009)

No	Protected areas	Surface area (ha)	Date of creation	Ecosystem type
1	Mpem and Djim National Park	97 480	2004	Tropical wooded savanna
2	Mbere Valley National Park	77 760	2004	Tropical wooded savanna
3	Boumba Bek National Park	238 255	2005	Tropical humid Savanna
4	Nki National Park	309 362	2005	Tropical humid savanna
5	Bakossi National Park	29 320	2007	Montane ecosystem
6	Mbanyang-Mbo Sanctuary	66 000	1996	Tropical humid dense forest
7	Lobeke National Park	217 854	2001	Tropical humid dense forest
8	Mount Oku Sanctuary	1 000	2005	Montane ecosystem
9	Mengane Sanctuary	26 711	2008	Montane ecosystem
10	Kangwene Sanctuary	1 100	2008	n/a
	TOTAL	1 164 842		

Table 6. General status of protected areas in Cameroon – 2008 (MINEP 2009)

Status	National coverage (ha)	Percentages (%)
Protected areas IUCN rated	3 482 741	7.00
Forest reserves	920 000	1.90
Under creation	975 091	2.10
Total area under protection	5 377 830	11.00
Safari hunting zones	8 138 800	18.00
Total area under protection and management	13 516 632	29.00

Institutional responsibility for protection of fungi in Cameroon is not clearly defined. Before conservation of fungi can proceed, this needs to be clarified. There are no mycological societies in Cameroon. Again, this is another vital infrastructural element for promoting fungal conservation. At present, only the African Mycological Association (www.africanmycology.org), and its recently formed African Workgroup on Fungal Conservation are in a position to help promote fungal conservation in Cameroon. Public knowledge of fungi and perception of the importance of fungal diversity and protection remains poor in Cameroon. This leads to a poor fungal conservation profile. There is also a gross shortage of appropriate personnel in the specialized fields of mycology, taxonomy and fungal ecology.

There is need for public and stakeholder education and training on fungal protection and conservation. There is a need to carry out nationwide fungal inventories in the different ecological zones and fields. There is need for an integrated, strategic approach to fungal conservation in Cameroon. Personnel and funding are required. Threat status listing of fungi in Cameroon urgently needs a national approach. Listing of species will hopefully trigger funding, research and management. To ensure adequate fungal protection, greater understanding of the relationship between vegetation and fungal communities is required. Contributions by non-experts are also vital for conservation. It is in the long-term interest of the government to provide funding for this work.

Table 7. Practical Measures for Habitat Recovery around Protected Areas in Cameroon (MINEP 2009)

Habitat type	Conservation priority	Intervener	Action taken / ongoing
Campo Ma'an	Highest	WWF, Tropical Int.	Reinforce existing PA's management activities Reinforce collaboration with logging industries
Mount Cameroon	Highest	DFID, GTZ	Create new core PA's Reinforce existing protected areas, management activities Develop target management plans
Douala Edea	Highest	Cameroon Government	Reinforce existing PA's management activities
Rumpi Hills	Highest	Cameroon Government	Reinforce existing PA's management activities
Kupe Mwanenguba	Highest	WWF, RBG Kew	Reinforce existing PA's management activities Establish sustainable funding mechanisms
Nki Bouba Bek	Highest	WWF/ USAID	Reinforce existing PA's management activities
Bamenda Banso Highlands	High	Cameroon Government	Sensitizes population on best conservation participation activities
Dja Faunal Reserve	High	ECOFAC, EU, USAID, WWF	Reinforce existing PA's management activities
Rio Del Ray	Moderate	FAO	Mangrove/ Fish protection
Takamanda Forest resources	High	WU	Reinforce existing PA's management activities
Bayang Mbo	High	WCS	Wildlife conservation measures
Limbe Botanic Zoological Garden	Highest	Cameroon Government, DFID, RBG, Kew	Conservation, education, research, domestication, GIS, survey systems

DFID = Department for International Development

GTZ = German Technical Assistance

RBG, = KEW Royal Botanic Garden, Kew

USAID = United States Agency for International Development

EU = European Union

FAO = Food and Agricultural Organization

WCS = Wildlife Conservation Society

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