A Review of Research on Cryptogams of Malawi for the Past 30 years (1987-2016): Progress, Challenges and Way Forward

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Abstract

Cryptogams are a unique group of plants whose ecological role in ecosystems is indisputable. Cryptogams are a key determinant of ecosystem biogeochemistry and known to support above ground biomass, control soil chemistry, provide habitats to nitrogen fixing bacteria and provide are food to other organisms. Compared with higher plants, cryptogams remain the least studied in Malawi and globally. This review aimed at assessing the scope and extent of research on Malawi's cryptogams, existing challenges and opportunities. A review of published literature between 1987 and 2016 was done using online search engines and library sources. This review showed that algae and bryophytes are comparatively well-studied groups represented by 70 percent (%) of all literature on cryptogams, particularly in Lake Malawi and Mulanje Mountain respectively. The ferns are the least studied, comprising just 15% of the reviewed literature. Further, no traceable study of lichens was encountered. Cryptogam research in Malawi is thus limited. This limitation could be due to lack of expertise in the field, limited laboratory infrastructure capacity and a general lack of appreciation for their importance. Considering the threat the different ecosystem in Malawi face, it is recommended that; local expertise, participation and infrastructure be improved so as to enhance cryptogam research in Malawi. Such an approach would ensure an increased local awareness of the value of cryptogams and foster informed conservation prioritization for cryptogams in Malawi.

Keywords: *Cryptograms, challenges, conservation, research gaps, Malawi*

1 INTRODUCTION

Malawi's flora is home to diverse groups of plants including Cryptogams. Cryptogams are a non-monophyletic group of seedless spore-bearing plants largely confined to moist habitats (von Konrat et al., 2011) such as rivers and river beds. As a group, Cryptogams include cyanobacteria, algae, fungi, lichens, bryophytes (Elbert et al., 2012) and ferns. These plants form mats on rocks, soils and trees and can survive harsh conditions such as droughts (Cornelissen et al., 2007). Cryptogams are important as they fuel food webs via photosynthesis and nitrogen fixation (Elbert et al., 2012), contribute to soil formation (Chen et al., 2000), influence soil chemistry (Li et al., 2007), act as food and habitat for other organisms, and facilitate growth of other seed plants (Sedia & Ehrenfeld, 2003). Compared to seed plants, cryptogams have generally received minimal research attention (George, 2000).

In Malawi, there still is a limited understanding of cryptogam diversity, their ecological importance and existing threats. According to Ryan (2002), cryptogams are elsewhere threatened by various factors, including a lack of data knowledge and awareness; ecosystem disturbance; fertilization of land for agriculture and use of herbicides This study aims to review research status and progress on Malawian cryptogams, assess the existing gaps, threats and propose a way forward.

2 REVIEW APPROACH

A review of published literature was done by using google scholar as a search engine with key yet broad search terms "Cynobacteria Malawi", "algae Malawi", "Lichens Malawi," "Ferns/Pteridophytes Malawi", and "Bryophytes Malawi". Initially the search was commanded for all possible publications before 1986. The search results with both terms in the title or with Malawi in the title had their abstracts reviewed. Later the search was limited to 10 year intervals (1987-1996; 1997-2006; and 2007-2016) to assess the progress made over subsequent decades. To assess local participation in Cryptogam research, publication titles were grouped into two themes: First, where the research was done (in Malawi or abroad), and second, who did the research i.e. by local authors (Malawians), foreign authors or collaboration. Finally, abstracts of all articles were synthesized to identify existing research gaps in the study of Cryptogams in Malawi.

3 RESULTS AND DISCUSSIONS

3.1 Cryptogam research pre-1987

Before 1987, there was little attention paid to cryptogams in Malawi. During that period, research on Malawian cryptogams was only restricted to algae and ferns. Such research includes a general description of algae in Mulunguzi River and Lake

Chilwa (Moss, 1970 & 1979). The ecology and phenology of ferns is Nyika were studied as part of the general Nyika plateau vegetation survey (Dowsett-Lemaire, 1985). A checklist of Zomba Mountain ferns was published earlier by Berrie (1984). Presently, there is no documented research on Cynobacteria, Lichens and Bryophytes of Malawi. Table 1 provides work done on Crytpogams of Malawi after 1986.

Table 6: *Studies done on four groups of cryptogams in Malawi for the past 30 years*

Period	Cryptogam Group	Research done	Source
1987-1996	Cyanobacteria	Their role in ecosystems (L. Malawi)	Bootsman et al., 1996
	Algae	Algal descriptions; Contribution to food webs; Checklist of algae flora	Haberyan & Mhone (1991) Hecky &Hesslein (1995) Cocquyt et al. (1993)
	Ferns	Ecology of Zomba ferns Checklist for ferns of Malawi	Berrie (1989) Berrie (1989)
	Bryophytes	Expeditions on Mulanje Mountain by BBS to identify and list Taxa	O'Shea (1993) BBS-Expedition, vol. 1-5
1997-2006	Cyanobacteria	Their abundance and biomass (In Lake Malawi)	Gasse et al. (2002 Yasindi et al. (2003)
	Algae	Ecology of L. Malawi algae Nutrient status within algae Algae as water quality indicators and Algae-zooplankton relations	Higgins et al. (2003) Guildford et al. (2000) Hecky et al. (1999) Ngochera (2006)
	Ferns	Relationships among bracken ferns in sub-Saharan Africa	Thomson et al. (2006)
	Bryophytes	Expeditions on Mulanje Mountain by BBS* to identify and list Taxa	BBS-Expedition, vol. 6-17
2007-2016	Cyanobacteria	Application as biomarkers Role in Nitrogen fixation Their photosynthetic role Climate change impacts (in Lake Malawi)	Castaneda et al.(2010) Castaneda et al. (2009) Guikdford et al. (2007) Gondwe et al. (2008)
	Algae	Algae as bio indicators Algal accumulation of heavy metals Climate impacts on algae Taxonomic revision	Kaonga & Monjerezi (2012) Kaonga et al. (2008) Maruyama et al. (2015) Shonohara et al. (2014)
	Ferns	None	na
	Bryophytes	Expeditions on Mulanje Mountain by BBS to identify and list Taxa	BBS-Expedition, vol. 19-19

*BBS: British Bryological Society

3.2 Progress in cryptogam research in Malawi

Algae and bryophytes have had adequate attention. As a group, algae are among the relatively well studied in Malawi. Most of this research has been done in Lake Malawi where algae play critical roles in food webs involving Malawi's treasured Cichlid fish. The compilation of the checklist for algae in Malawi (Cocquyt et al., 1993), an understanding of their ecology (Hecky & Hesslein, 1995; Higgins et al., 2003), the clarification of how they are impacted by climatic variability (Castaneda et al., 2009) and their proved applications (Hecky et al., 1999; Kaonga & Monjerezi, 2012) are critical facets that shall ensure informed studies and utilization of algal taxa in Malawi. Further studies of this group in other freshwater ecosystems in Malawi still lag far behind. With the existing baseline data, future efforts should thus focus on these neglected ecosystems.

Much of the research on bryophytes of Malawi dates back to 1993 when the British Bryological Society (BBS) began expeditions on Mulanje Mountain. These expeditions were aimed at identifying bryophytes and providing phytogeographical and ecological data to inform conservation prioritization (Longton, 1993). Since these expeditions began, different major bryophyte groups have been identified and described. These include Liverworts (Hodgetts & Eszterhazy, 1999), Mosses (Enroth & Hodgetts, 1996; Frahm & O'Shea, 1996), and Hornworts (Pocs & Vana, 2015). Even after more than 25 years of such research, there still are new records of bryophyte taxa being described (Wilbraham, 2015) with some being quite rare (Pocs & Vana, 2015). These recent discoveries point to the possibility of more new taxa present on Mulanje Mountain and more so in other ecosystems in Malawi that are yet to be studied.

3.3 Challenges Facing Cryptogam Research in Malawi

The challenges limiting research in cryptogams in Malawi are diverse. Broadly, scientific research in Malawi (just as in most developing countries) is driven by its relevance and anticipated direct benefits. This has led to the promotion of applied research or mission oriented research (Vose & Cervellini, 1983). The existing limited information or knowledge on the importance of cryptogams could in part contribute to the challenges. For Malawi however, challenges towards cryptogam research can be categorized into four namely: fragmentation of research efforts; unaddressed basic research gaps; a lack of clear cryptogam conservation strategies; and inadequate local expertise, infrastructure (lack of equipment for identification) and a lack of local participation.

3.3.1 Fragmented efforts

The fragmentation in research relates to coverage. While Malawi contains diverse ecosystems, the studies have focused on just few of these. Even though this review shows that the cryptogam group is inadequately researched, research on algae and bryophytes has been limited to at most one ecosystem; Lake Malawi in case of algae and Mulanje Mountain in the case of Bryophytes. Malawi has different ecological zonation, a scenario that could potentially support variation among cryptogams both in terms of species diversity and abundance. There is therefore an urgent need to compile cryptogam checklists for cryptogams in all ecosystems (parks, game reserves, mountains, and river systems). This urgency stems from the accelerated loss and degradation of some of these ecosystems occurring now.

Among the four groups of cryptogams reviewed, lichens and ferns are the least studied. No published literature on Malawian lichens was found during this review. Lichens are only mentioned during discussions of general ecological processes, where they are involved. The few documented studies mostly involved identification records (Krog, 1993). On the part of ferns, not much has been done in Malawi since 1986. The only traceable studies include the ferns of Nyika Plateau by Dowsett (1985), the ferns of Zomba Mountain and and a checklist of Malawian ferns (Berie, 1989; Burrows & Burrows, 1993). Checklists are important as they provide a basis for further research. However, they can be considered as basic, thus further research about ecology, socioeconomic value, conservation threats among others more could provide a more clearer understanding of these plant groups in Malawi.

3.3.2 Existence of critical research gaps

For all the studied taxa, there remain gaps in research that require urgent filling. Of critical importance is data on existing threats to the diversity Malawi's cryptogams. While the general threats could be known, there are likely threats that are ecosystem specific. Linked to this is a lack of data on distribution and abundance of Cryptogams in the country. The lack of checklists for most ecosystems hinders acquisition of a clear understanding of the existing threats. For the adequately studied cryptogams of Mulanje Mountain, there lacks a clearly defined conservation strategy. Further, regarding conservation, all Malawi's cryptogams require a conservation needs assessment. The existing conservation efforts of various ecosystems, where cryptogams are found, do not clearly reflect the ecological roles and requirements of the various cryptogam groups.

3.3.3 Lack of conservation priorities

Some cryptogam taxa found on Mulanje Mountain are categorized as rare and more of such taxa could be found in other ecosystems. There is thus a need to come up

with conservation strategies to protect these rare taxa countrywide. The recording of new bryophyte taxa by Wilbraham (2015) point to the possibility that there potentially exist other unidentified taxa in other ecosystems. With the current accelerated forest losses, other potentially unidentified taxa could become locally extinct without a record.

3.3.4 Inadequate local expertise, infrastructure and local participation

Compared to other countries in the region, cryptogam research in Malawi lags far behind. There are likely a lot of confounding factors to this scenario. Malawians cryptogams are generally the least known globally. The lack of ethnobotanical value of cryptogams makes this group largely unrecognized by local communities and policy makers alike. The perceived lack of use translates into lack of importance and consequently dwindled research and conservation efforts. Research in plant sciences in Malawi has mostly focused on plants with commercial, medicinal and nutritional values at the expense of cryptogams.

There is also limited human resource in botanical sciences coupled with a lack of well-equipped laboratories. Although experts on cryptogams are also scarce elsewhere (Hallingbäck, 2007), the situation is more critical in Malawi. A case in point is the presence of just one technician at the National Herbarium and Botanical Grades of Malawi, with capacity to identify some cryptogams. Presently, Malawi does not have specialist in lichens. These shortfalls have contributed to limited scientific research in cryptogams in Malawi, incapacitating potential innovations involving cryptogams. There is also limited collaboration with international research institutions that work on cryptogams. This is evidenced from the works reviewed in this study, which is predominantly undertaken by international experts (Figure 1), with minimal national collaborating experts.

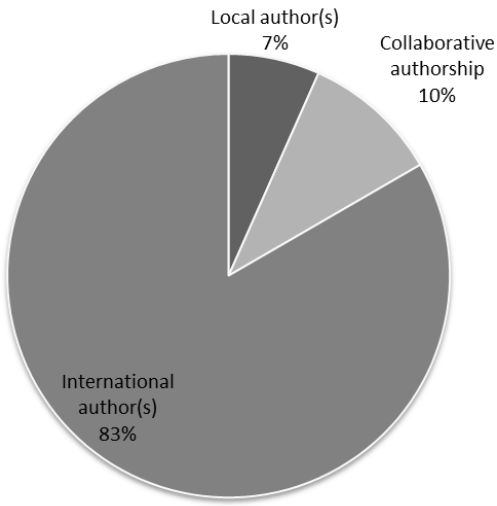

Figure 6: *Traceable publications on Malawian cryptogams by author affiliation; (local, international or by collaboration, Data from 1980-2016.*

The lack of local expert participation in part has led to research being localized to just those ecosystems that are of interest to the international experts, at the expense of other ecosystems critical to the country.

4 CONCLUSIONS AND RECOMMENDATIONS

Based on the progress done and challenges still prevalent, it is recommended that checklists for all cryptogam groups for all ecosystems should urgently be developed for Malawi. For the well-studied cryptogams, there is also need to formulate appropriate conservation strategies. Further, the local botanical community should actively participate in cryptogam research singly or in collaboration with international experts. In addition, improving cryprogram research facilities such as laboratories in research institutions is key to enhancing research in this plant group and in training more cryptogam experts (especially in the area of identification), developing relevant handbooks and identification keys. Since plant conservation can be easier where people can directly accrue benefits, an assessment of the ethnobotanical value of cryptogams needs to be done so as to elucidate their importance to ecosystems and humanity. Considering the existing threats to all floras in the country, such measures are a matter of urgency. Malawi's cryptogams are likely a unique assemblage and a clear understanding of their ecology, abundance and distribution is fundamental. Such an understanding could provide avenues through which cryptogams could be of use in addressing some of the most pressing national environmental and socio-economic issues.

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