African Journal of Agricultural Research Vol. 7(31), pp. 4352-4356, 14 August, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.1216
ISSN 1991-637X © 2012 Academic Journals

Review

A review of Nigerian Bryophytes: Past, present and future

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Accepted 6 July, 2012

This paper reviews the "state of art" in bryological research activities conducted in Nigeria. It briefly introduces bryophyte distributions, descriptions, and usages. Others are habitat types, nutrition, phytochemistry, and reproductive ecology. The significance of bryology to agriculture was reviewed. From the trend of discussion, the potential effects of agricultural activities on bryophytes were evaluated. It is therefore, evident that the state of art in bryology is moribund in Africa as a whole and Nigeria in particular as we currently have six active bryologists in Nigeria.

Key words: Nigeria, bryologist, ecology, nutrition, phytochemistry, reproduction, agriculture.

INTRODUCTION

It is unquestionable that bryologists have a role today that far exceeds that of the past. Inability to place bryophytes into the context of current ecological perspectives has called for the need to fill our knowledge gap. Lack of taxonomic descriptions of many taxa makes ecological research impossible. Because of scattered formal efforts, taxonomists and general plant ecologists have only made ecological observations as they describe their species collection. Published taxonomic information about African bryoflora has been widely scattered in the literature (Chua-Petiot, 2001, 2003; Chua-Petiot and Pócs, 2003; Egunyomi, 1979, 1980, 1981a, 1984a; Egunyomi and Vital, 1984; Kis, 1996, 2001; Poćs and Lye, 1999). This has caused increasing "red lists" of endangered species due to lack of information about the current bryological surveys. Before we can further consider these problems in any context, we need to know the position occupied by bryophytes within the plant kingdom. Bryophytes are ranked the second largest group of plants with about 25,000 species, exceeded only by flowering plants (Magnoliophyta) with about 350,000 species (Gradstein et al., 2001, Crum, 2001). Moreover, everyone involved realizes that we have little knowledge of the contributions of bryophytes to our environment and agriculture.

Ecosystem biologists have now realized the potential role of bryophytes in nutrient cycling and water retention capability of bryophytes. The medical scientists understand better the gene function and protein synthesis and environmental scientists now show interest in monitoring for heavy metal pollution and prospecting for mineral oil using bryophytes.

History of Bryophyte taxonomy and systematic studies

Dating back to 300 BC, there was little mentioning of bryophytes in the literature (Theophrastus, 1916). Absence of fossil records further made it more complex to identify the intermediate plant between bryophytes and algae. This led to the grouping of algae, liverworts, mosses, and ferns as the cryptogams (hidden sex plants). Moreover, the earliest land plants (440 to 410 m.y.a.) appear closely related to ferns. It may be possible that liverworts evolved simultaneously with the fern allies. Therefore, the positions of bryophytes in the evolutionary ladder remain isolated.

The history of the naming of bryophytes is nearly 300 years (Watson, 1978). Taxonomic studies on African bryoflora remain the problems of the tropical bryologists. African bryologists encountered many difficulties in identification and naming of tropical bryophytes which stemmed out of inadequate monographic treatments of families and genera. In recent times, the few active bryologists in East Africa have exhaustively collected several species of liverworts from Kenya, Ruwanda, Tanzania, Uganda, Zaire as well as, Madagascar (Poćs, 1982, 1999, 2001, 2002; Poćs and Lye, 1999; Kis, 1996; 2001; Kis and Pócs, 2001; Chuah-Petiot, 2001; Chuah-Petiot and Pócs, 2003). Many of the East African liverworts have been identified, classified and published. Chuah-Petiot (2003) has exhaustively described the mosses, liverworts and hornworts in East Africa Kenya. However, published history of bryophyte studies in Nigeria started at about the mid-1970s and to date not much have been achieved. In recent times, few published indigenous works in Nigeria focused, among others, on descriptions and provisional keys of some mosses in Southwestern Nigeria (Akande, 1992; Egunyomi, 1984a). Thus, the study of bryophytes in Nigeria is in its “infancy” stage in perspective of the world records. From the foregoing, the published record of survey of world bryophytes to reflect the existence and how new species arise is incomplete because contributions from Africa are insignificant compared to the rest of the world. Thus, the distribution of families, genera, and species reflect the history of bryophytes worldwide.

History of Bryophyte distributions in Nigeria

Despite the extensive gap in existing knowledge of the bryoflora at all taxonomic levels of many countries of the world, bryophytes tend to show wider distributions than the flowering plants (Watson, 1978). Information concerning detailed composition of the bryophytes of many continents has been documented (Schultze-Motel 1963; Van Zanten, 1964; Poćs, 1982; Robinson, 1967). Poćs (1976) and Oyesiku et al. (2010), showed correlation between the tropical African and Asian bryoflora. However, few published information exists about bryophytes and their distribution in Nigeria (Egunyomi, 1978; Egunyomi and Vital, 1984).

History of Bryophyte habitat ecology

Habitat ecology is another interesting aspect of study of bryophytes. Many nineteenth-century bryologists knew well the habitats of many bryophytes that they studied. However, they were not experimentalists. The experimental side of bryophyte ecology came to the limelight 79 years ago or so. The paucity of knowledge of habitat ecology of bryophytes is because of lack of interested workers, who instead, have focused their attention mainly on higher plants. Despite this paucity, the six bryologists in Nigeria have the species checklist from a defined habitat as a valuable starting point for ecological studies. The majority of these works came from the Southwestern part of Nigeria (Egunyomi, 1979, 1980, 1981a, 1984a; Makinde and Odu, 1993). The habitat list not only serve as a framework of useful information, but also tells us at a glance, the contrast between the tree bryophytes and those of rocks and moreover between the colonists of inselbergs rock and pioneers on decaying logs. Such habitat list is valuable and with gain if consulted. From such species list, we may learn the value of indicator species, for example *Calymperes erosum* and *Erythrodontium barteri,* which point at a glance to shade conditions or the species of *Archidium acanthophyllum*, which points to open conditions. Moreover, there are those species with restricted habitats that their presence on a list may indicate the actual prevailing conditions. For example, *Fissidens* spp., growing on abandoned termite hills or heap of red earth. In addition, the mixture of liverworts (*Lejeunea* spp.) and moss (*Thuidium* spp.) seems highly suggestive of fine-grained substrates (Ishikawa, 1974). Furthermore, species vertical distributions on trees may also suggest the species preference to any special height zone on the tree trunks.

Substrate pH (6.7 to 7.7) seems to influence the special association of two unrelated plants for example, moss (*Archidium acanthophyllum*) and succulent grass (*Cyanotis lanata*). The earlier laboratory studies indicated optimal growths of a moss at a pH of 7.5 and with below pH 6.0 growths are retarded (Streeter, 1970). Hence, the knowledge of the association of the unrelated plants and their interaction with substrate factors is noteworthy. From the foregoing, a list of indicator species from a given habitat is informative.

Given to the bryophytes habitat information, bryology has a great relevance to agriculture in many ways. Simon (1975), demonstrated that bryophytes could be used as indicator of soil quality. The coarse textured mosses increase water storage capacity and fine textured ones provide air spaces in the soil (Ishikawa, 1974). Bryophyte screen not only helps protect soil from wind and water erosion, it is also providing suitable habitats for nitrogen fixing colonial endo-symbiont Cyanobacteria. A typical example is Nostoc, which enters the hornwort (*Phaeoceros* spp.) and is established (Renzaglia and Vaughn, 2000). The habitats which provide important information on the diversity of epiphyllous bryophyte communities can be used as an important tool to detect any depletion of forest ecosystem due to agricultural activities and other disturbances caused by humanity (Hallingback and Hodgetts, 1996). Bryophytes are efficient soil binders that regulate the soil moisture and prepare the soil for future plant succession (Alam et al., 2012). Given to their trampling resistance and high regenerative ability, bryophytes help prevent water erosion on bare ground. In his home garden, the present author found that an urban moss *Hyophila crenulata was* an important fast recolonizer of the garden sprayed with weed killer chemical (Round-up), and observed to reduce erosion by binding the soil surface with its cotton wool-like protonemata before other plants reestablished. Welch (1948), found that bryophyte germinating spores, vegetative (gametophyte) fragments and other asexual propagules (gemmae and tuber) form a binding film over exposed soil.

History of nutrients cycle involving Bryophytes

In the 1950s to 1980s, the importance of bryophytes in mineral nutrition of natural ecosystems attracted attention. The elements requirement for bryophyte growth is similar to those of higher plants (Salisbury and Ross, 1969). Reports in North Wales stated that mosses mixed with grasses in pastures take most of the available phosphate in the soil (Richards, 1959). In the 1980s, attention shifted to determination of mineral nutrient of some tree (corticolous) bryophytes in Nigeria (Akande, et al., 1985). Sugawa (1960) argued that dried moss seems to be sweeter than the fresh ones, and that it stimulates the growth of animals. It has been found that powdered *Barbella pendula* can be added to the food of chicken and puppies with no side effects. In the 1980s and 1990s, there were more investigations on feeding interactions between animals and bryophytes; another relevance of bryology to agriculture (Prin, 1981; Gerson, 1982, 1987; Davidson, 1990).

History of uses of Bryophytes

In Saxon times (5th and 6th centuries), mosses were regarded unimportant either in medicine or in earliest herbarius (Anonymous, 1484; Cockaine, 1864), instead, lichens appear recognized as a valuable plant in medicine. It was much later that both lichen and bryophytes were illustrated, but the latter was not well defined in the herbal records. Dillenius (1741), in his general history of the land and water, wrote a comprehensive book “Historia Muscorum” with illustrations of bryophytes; a significant work of the lower plants (cryptogams). However, further attempt to discover the complete life history of bryophytes proved abortive and the origin of bryophytes remained a topic for speculation for many years (Haskell, 1949; Richards, 1959; Anderson, 1974).

In the recent past, claims made showed that bryophytes were weeds of no economic or pharmaceutical importance (Thieret, 1956). Moreover, the phytochemical study of bryophytes for pharmaceutical “lead” compounds has been neglected because of their tiny nature which makes it difficult to identify and to collect large quantity of pure sample for producing drugs (Asakawa, 2001). However, recent studies of mosses and liverworts *in vitro* have shown that they synthesize distinct antibiotically active substances (Dulger et al., 2005; Ilhan et al., 2006; Ojo et al., 2007). Moreover, various secondary metabolites present in bryophytes are responsible for the bioactive. Such metabolites are effective as antitumor, antibiotics, anti-fungal, anti-feedants, and repellents (Huneck, 1983; Spjut et al., 1986; Brinkmeier et al., 1999; Asakawa, 2001; Harinantenania et al., 2006; Sabovljevic et al., 2006). Asakawa (2001), reported on complex phenolic compound bibenzyls among the liverworts. The only metabolite not found in moss is alkaloid. According to Mann (1978), primitive plants contain tannins whereas the modern plants contained alkaloids. This translates to mean that bryophytes are primitive in nature.

The studies of impact of air pollutants on bryophytes have gained wider publicity in many continents of the world. The most important air pollutants associated with bryophytes include sulphur dioxide, lead (and other heavy metals), hydrocarbons, and nitrogen oxides. Bryophytes are sensitive to sulphur dioxide, which causes serious damage to their chloroplasts. Very little appears to be known about pollution impact on bryophytes in Nigeria. Few indigenous scientists in Nigeria have studied some mosses for their efficiency as indicators of atmospheric heavy metals (Onianwa and Egunyomi, 1983). Recently, two indigenous mosses (*Calymperes erosum* and *Erythrodontium barteri*) appeared to be excellent biosorbents of trace concentrations of heavy metals in solutions (Babarinde et al., 2007, 2008).

History of asexual reproduction and regeneration in Bryophytes

In the 1980s, survey of reproductive organs in Nigerian bryoflora came to the limelight (Egunyomi, 1981b, 1984b). It is an undeniable truth that asexual reproduction plays an important role in the distribution of some mosses. In Southwestern Nigeria, asexual method of reproduction is prevalent among the indigenous mosses and liverworts (Egunyomi, 1982). Prevalence of the bryophyte populations correlated with the habitat and distribution. Studies on asexual reproduction constitute about 15% of the African bryoflora (Egunyomi, 1984b). Besides, asexual diaspores (gemmae) are readily used to distinguish species from the same genus. Examples include *Calymperes* spp., *Philonotis* spp., *Leucodontopsis* spp., *Jaegerina* spp., and *Barbula* spp.

However, opinions differ on the efficiency of sexual and asexual reproduction as regards spread of bryophytes. In the 1960s and 1970s, most studies on the importance and efficiency of sexual and asexual reproductions were reported in Europe and other parts of the world (Anderson, 1963; Longton, 1976; During, 1979). Other strategies of population spread in a bryophyte include polysety and regeneration. The former is uncommon and known in a few group of mosses.

Polysety is a situation where more than one seta emerges from a single inflorescence. The mechanism behind polysety is not fully known, but may be because of simultaneous fertilization of two or more individuals of archegonia, aided by sugary exudates from the mature archegonia. Longton (1962), reported polysety in 66

British acrocarpous mosses and a single pleurocarpous moss. Concerning regenerative capacity of mosses, the success of mosses colonizing localities beyond the climatic limits of sexual reproduction have been argued to be due to regeneration capacity of any part of the moss caused by mechanical trampling. The pioneering work of Heald (1898) had stimulated La Rue (1942) and other authors (Gemmell, 1953; Chopra and Sharma, 1958; Macquarie and von Maltzahn, 1959; Lersten, 1961) to study regeneration in bryophytes. In Nigeria, available publications on regeneration are those of Egunyomi et al. (1980) and Olarinmoye (1981). Since then, there has been no published work on regeneration of African bryophytes to date.

DISCUSSION

From the foregoing, the present review elucidated the need to bridge the gap in knowledge of bryophytes between Africa and the rest of the world. The claim that about 25,000 species of bryophytes exist in the world may not be true because the few sub-Saharan bryophytes deposited at the Herbarium in Missouri Botanical Garden are records of 1960s and 1970s. No significant record occurs of African bryoflora in any of the herbaria in Asia. In 2009, Oyesiku funded CAS-TWAS VS Fellowship, travelled to China and donated 100 species of bryophytes from southwest Nigeria to the herbarium, Institute of Botany, Chinese Academy of Science, Beijing, China. This is part of the efforts to tell the bryologists out there that only a few active bryologists are working independently in one corner of Nigeria with their personal resources. The limiting factor is inadequate funding of researches and non-availability of modern equipment to conduct laboratory experiments. All of these contribute to an increasing “red list” of African bryophytes and bryologists.

In addition to the aforementioned problems facing African bryologists, the potential effects of agriculture cannot be overemphasized. More frequent and regular disturbances such as plough, deforestation and bush fires caused low bryophytes richness and diversity, while low and regular disturbances produce high richness and diversity. Zechmeister and Moser (2001), concluded that decreasing land-use intensity yield a significant increase in total bryophytes and their diversity.

CONCLUSION

Habitat destruction in many countries of the world is a major threat to bryophytes, especially, the ones with narrow amplitude and geographical restriction (endemics). It is with great regret that tropical forests is persistently being invaded and deforested for human population expansion and use in agriculture. The future looks bleak for the bryophytes.

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