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Mass flowering and death of bamboo: a potential threat to biodiversity and livelihoods in Ethiopia

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Abstract

Flowering and hence seed setting is the most infrequent phenomenon in most bamboo species. Seed setting in bamboos most often occurs gregariously for all the plants irrespective of age and/or location within and among populations. Seed setting in most bamboos is followed by total death of all the plants, which might havoc the whole ecosystem and lives dependent on bamboos. Such flowering in bamboos occurs in an interval of 10 to 120 years depending on the species. Ethiopia is represented by two naturally growing bamboo species; the highlander *Arundinaria alpina* and the lowlander *Oxytenanthera abyssinica*. With these two species, Ethiopia contributes the larger fraction in Africa accounting for about 67% of bamboo coverage of the continent. Recently, the rare event bamboo flowering has occurred in Ethiopia covering more than 85% of the lowland bamboo in all three zones of Benishangul Gumz and Awi zone of Amhara regional states and 60% of highland bamboo in Dawro zone of Southern Nation and Nationalities regional state. Despite the fact that flowering thereby seed setting is a blessing phenomenon for a more genetically diverse next generation, it usually leads to death of bamboo plants which might threaten the entire ecosystem and livelihoods of these areas. This paper presents details of bamboo populations which are currently in seed setting in Ethiopia and potential consequences compared with experiences in bamboo species from other countries. The paper further provides measures and directives to be considered in order to save and regain the bamboo populations.

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Introduction

Bamboo is a common name for woody and herbaceous grasses in the subfamily *Bambusoidea* that are assumed to be over 1500 species being spread in more than 75 genera (Ohrnberger, 1999). Bamboos share a huge portion of global forest ecosystem with a wide range of ecology that extends from tropics to temperate and also elevations from sea level to 4000m (McNeely, 1995). They are found in all of the continents except Antarctica where plants hardly survive. In all of the continents where they are found presently, they grow naturally except in Europe where yet are well introduced. Naturally, they are mainly distributed between N46^{o} and S47 ^{o}, but mainly still higher concentration in a wide zone between the Tropic of Capricorn and the Tropic of Cancer (McNeely, 1995). Worldwide, 22 million hectares of land is assumed to be covered by bamboos (ICBR, 2004).

Ethiopia contributes the largest coverage of bamboos in Africa, giving out more than 1 million hectares. This constitutes about 67% of the total area of bamboo in the continent (Embaye, 2000) which is estimated to be about 1.5 million hectares (Kigomo, 1988). Bamboos in Ethiopia are represented by two species, *Oxytenathera abyssinica* (A. Rich) Munro; the lowland bamboo which accounts 85 % of the total national coverage and the rest 15% is covered by *Arundinaria alpina* K. Schum.; highland bamboo (Embaye, 2000; Embaye et al, 2003).

Most bamboos including the Ethiopian ones flower only once in their life and die then after to set seed. The natural causes that trigger bamboos to flower still remain beyond the scope of science and hence the event is considered as a botanical Enigma. The event appears in a cyclic pattern in an interval of 10 to 120 years (Ramanayake, 2006) depending on the species and ended up with total death. All individuals of a population flower at the same time irrespective of the size and age of shoots. The event is even mightier for some species in that all individuals flower all over the world at a time.

Despite the fact that flowering result in seed setting which is a blessing for more genetically diverse next generation, the gregarious flower and seed set demands the plant to spend extremely high energy which ends up with the death of the whole plants which causes total losses of bamboo populations (Miyazaki et al, 2009). Recently, gregarious flowering of bamboo has been observed in both the lowland and highland bamboos in Ethiopia in different districts of the country (Fig 1). Accordingly, the situation has caused potential threats to the ecosystem and lively hoods of the areas where it occurred in the country. This paper presents details of bamboo populations that are currently in seed setting and potential consequences comparing with experiences in bamboo species from other countries. It further provides measures and directives to be considered in order to save and regain the bamboo populations in the regions via seeds.

Materials and methods

This paper is compiled based on field observation, review of literatures, interview of the local community and experts at different level in regions where flowering is occurring. In order to obtain on site information Bamboo research team from Ethiopian Institute of Agricultural Research visited bamboo growing areas: Accordingly, the team made field observation of Tocha and Merkan district of Dawro; Masha district of Mizan-Tepi zones in Southern Ethiopian; Enjibara (Banja, Wagusa Shekudad and Fagita Lekoma) district of Awi Zone in Amhara and Seka, Gera, Goma, and Mana districts of Jimma zone in Oromia regional states for the highland bamboo. Likewise field assessment was made in eight districts of three zones in Benishangul Gumz regional state for lowland bamboo flower assessment. It further compiled available information from respective zonal and district agricultural and rural development offices. In order to verify the office records and field observation, 10-12 local community members were interviewed from each selected three districts namely, Tocha in

Dawaro, Enjibara in Awi and Komosha in Assosa zones.

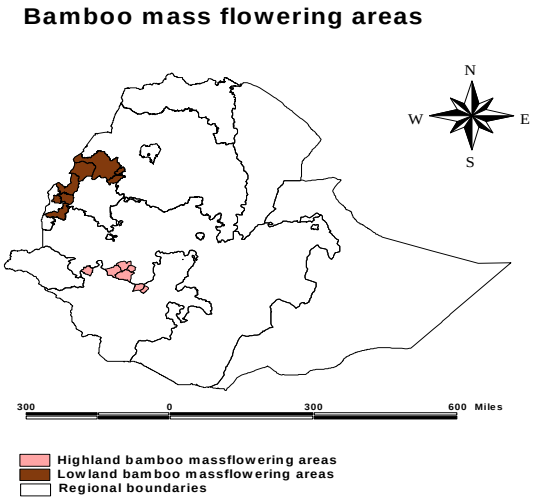

Fig. 1. Bamboo mass flowering areas in Ethiopia.

Results and discussion

Field observations and communication

Historical records:

Records show that the highland bamboo flowers more infrequently than the lowland one. According to the information obtained from both local communities and expertise, there had been similar stories on bamboo of Dawro Zone in southern Ethiopia before 100 years during which also the entire bamboo was devastated in the area. Then after, bamboo was reintroduced from Kefa by the local king named Hailetsion (locally, Kao Kenssa) at a place called Tuta in Tocha district which many people currently think this population as natural bamboo forest. This date was also before 100 years. Some of the old local community members and the experts claim that the source of all bamboo in Dawro zone was Tuta which is also currently in mass death (Fig. 2). The current mass death of bamboo in Dawro started in 2009 and has been expanding since then. Presently, it has been estimated that more than 66% of the total 1483.25ha of bamboo in Tocha district is under mass flowering and thence mass death. This mass flowering is expanding to the neighboring district named Merkan, vanishing all the plants synchronously.

Three independently interviewed local community members from same place indicated frequent flowering of some bamboo plants in a population in their area but it had never been seen dead like the current situation. With the exception of these, the rest of the interviewee had neither seen nor heard such mass death of bamboo after the aforementioned over 100 years record.

Fig. 2. Tuta bamboo in Dawro-Tocha presumably the first population in Dawro Zone (Photo: Demissew Sertse).

Fig. 3. The recurrently flowering highland bamboo Enjibara at St. Johannes Church (Photo Demissew Sertse).

At enjibara, there has not been record of mass flowering of cultivated bamboo so far despite the fact that there is long history of bamboo cultivation in the area. However, some of the local community members recall mass death of wild bamboo before 45-50 years. The areas where they mentioned mass flowering are currently covered by other vegetation

and no bamboo is observed in these areas. We observed flowering of bamboo (Fig. 3) at small patch in the compound of St. Johannes Church about 7km from Kosso-Ber on the way to Bahir-Dar. The villagers said that this happens every year and they claim that it is different variant which they call it Agericha. We observed flowering of this bamboo before one and half year ago as well.

Fig. 4. *Oxythnathera abyssinica* flowering over vast area of Komosha, Benishangul (Photo: Demissew Sertse).

Flowering in lowland bamboo seem to be more frequent. According to the local community, it flowers every 30-35 years. Records from Benishangul Gumz regional office of agriculture and rural development, natural resource department indicate that the present mass flowering started around seven years ago around Guba and Mankusha areas of Metekel Zone. Currently, mass flowering thereby mass death has reached over 85 % of the estimated total 400,000 ha bamboo in the region (Fig. 1 & 4). The bamboo forest which is locally called 'Ambesa Chaka' (lion forest) in Bambasi which spread over 7,500 ha of land was the only remaining major bamboo forest in Benishangul-Gumz region when based on assessment made in December 2010 where actually some plants started to flower. In other field assessment made in July 2011 the whole bamboo of this forest already flowered. Although the early flowered areas regenerated and have formed bamboo forest, remarkable former bamboo land has been changed to other land use system. The remaining also is critically challenged by wild fire which is traditionally set as management of range lands in the region.

Awareness and perceptions of the local communities

Most of the local communities in Dawaro perceive the phenomenon as abnormality caused by certain disease infection. They justify their perception with an excess excrete that is coming out from stump of bamboos that are cut after flowering which normally did not happen in bamboo stumps before flowering (Fig. 5). Furthermore, they strengthen their perception with the synchronously continuing move of the problem from one population to another as typical character of an epidemic disease. All the interviewed community members do not believe that the pheromone provide seed. They argue that despite their effort to assess possible seed set, they have never come up with seed. Indeed, the majority of flowering bamboo seems to end up with no seed. In February 2010, group of the researching team able to find few seeds from single patch. During second assessment in December 2010, the team could not find any seed among the flowered populations assessed. So far, there is also no record of new regeneration under dead populations.

Fig. 5. Exudates excreting from flowering stump but not from normal stumps (Photo: Demissew Sertse).

The local communities in the flowering lowland bamboo areas know that the event provides seed. Many them in different bamboo mass death areas are

also participating in collection and selling of seeds to different organizations. There also is quite a lot of newly regenerating seedlings under the dead populations. The communities however, still believe that the phenomenon is associated with certain disease. They also believe that there is high prevalence of trypanosome disease and subsequently death of large number of their animals in bamboo flowering years.

Fig. 6. Mt Gubel, Enjibara which had been covered by bamboo 45-50 years before (Photo: Demissew Sertse).

According to these community members, wild animals that were seen commonly such as lion and bush backs have now migrated out since the area has become open due to mass death of the bamboo.

Consequences of flowering in Bamboos:
The flowering event of bamboos might be a blessing in disguises having both positive and negative consequences.

Positive aspects of bamboo flowering:
Bamboo flowering and hence seed setting is seen as a blessing phenomenon in that it gives a chance to have genetically more diverse next generation. Most bamboo populations are established through vegetative propagations. Sometimes a population might be of a single rhizome clonally extended to a vast area. Hence, all individuals of a population might have same genetic makeup (Stern, 2004). This might result in total loss of the population if a certain disease or pest rises. Flowering creates the opportunity of gene mix up and the next generation via seed can have more genetic diversity. Bamboo is an out crossing a wind pollinated plant where there is high gene random mix up.

Apart from the advantage of genetic diversity, seeds are easier to handle, transport and store for long time. As a result of lack of seeds, propagation in bamboos remains mainly to be vegetative, which mostly require planting rhizomes together with the whole Culm. This constrains the transportation of planting materials long distances and in large amounts. In addition, such planting materials are viable only for few days which affect their success after being transported long distances. Seeds therefore provide chance to be stored as germmaterial *ex situe* such as in genebanks for long time, transported long distances for safe establishment of new plantations and easy to handle..

Negative aspects of bamboo flowering:
The gregarious flowering and subsequent death of all bamboos of over vast area causes big ecological havoc and threatened the livelihoods of the area.

Impact on physical environment:
Study results indicate that there is a significant depletion of soil nutrient in dead bamboo sites (Takahashi *et al*., 2007). This is argued to be the effect of microbes as nutrient sink in dead bamboo sites where there is not further source (Rai, 2009). The total population failure after bamboo death leaves the land bare and takes at least few years for a bamboo to regenerate again (Ramanayake, 2006). Subsequently, soil erosion, landslides prevail (Helen Keller International, 2008).

Under proper management bamboo has been found to sequester as large carbon as many fast growing trees in plantations able to do (Lugt *et al*, 2009; Yiping *et al*, 2010). In contrast, mass death of bamboo may result in the release of high volume of carbon stored in its body to the atmosphere and

hence contributes rising up of temperature (Yiping *et al*, 2010). The current mass death of bamboo over vast areas in Ethiopia seems to consequence release of big volume of carbon dioxide to the atmosphere.

Threat of permanent loss of bamboos after death:

Once the entire population is dead, it will take a couple of years for new cohort to regenerate again. Unless the area is protected, it might also result in permanent loss of bamboo. The sensitivity of the newly emerging seedlings and possible change in land use can also be a problem. A decade ago, the mass flowering and subsequent death of vast population of lowland bamboo in Benishangul-Gumz regional state of Ethiopia, Metekel Zone, Mandura district, left only few surviving patches in the area after new regeneration which the rest of the bamboo area has been converted to other land uses (Embaye, 2006; Statz, *et al*., 2007). Similar stories were recorded for highland bamboo in Southern Ethiopia, Sheka Zone, Masha district where farmers gave up bamboo after its death and converted lands to Enset (Adnew and Statz, 2007). The newly regenerating young bamboo plants might be constrained by fire which is traditionally set as management of range lands particularly in Benishangual Gumuz region. The effect of fire to bamboo seedling however is debating. Some authors claim fire favouring bamboo seedlings (Keeley and Bond, 1999; Franklin and Bowman, 2003) while others are arguing against this idea (Saha and Howe, 2001). Abortion of flowers in highland bamboo in Dawro Zone might also be a challenge to regain the resource back via seed. This situation seems to be as a result of resource exhaustion during flowering and hence the plant dies before setting seeds (Miyazaki et al, 2009). The abandoning of natural bamboo forest after flowering 45-50 years ago around Enjibara areas; at Mt. Gubel (Fig. 6) might also be connected to failure to set seed. All of reports cautioned bamboo flowering as the major factor for declination of bamboo coverage in Ethiopia. Therefore, bamboo death sites should get due attention in order to promote the newly emerging seedlings.

Threats to species associated with bamboos:

There are many specialized species dependent on bamboos for food or shelter. For example in Asia Giant Panda (*Ailuropda melanoleuca*), Red Panda (*Ailurus fulgens*) and the Himalayan Black Bear (*Selenarotos thibetanus*) are reportedly strongly dependent species on bamboos (Bystriakova *et al*. 2003). The authors further mentioned some 15 Asian bird species exclusively living in bamboos. Likewise, in Ethiopia, some species are believed to have strong association with bamboo. Recently, Mekonnen *et al*. (2010) reported that the endemic Bale Monkeys (*Chlorocebus djamdjamensis)* in Ethiopia is highly dependent feeding on bamboo (*Arundinaria alpina)* which as a result also is confined in bamboo forests. According to Komosha district agricultural and rural development office record, a rodent a little bit bigger than the ordinary rat is assumed to be highly confined in bamboo forests. This suggests the current mass flowering and subsequent total death of bamboo in Ethiopia to be a potential threat to such species strongly associated with the species. Lion also seem to have preference of bamboo forests. Ambessa chaka (lion forest) which is dominantly covered by bamboo is known to be home of lion. The local community members in Komosha district also claim bamboo as intimate habitat of lion. Hence, apart from species highly specialized to bamboo ecosystem; partially dependent species may also be threatened due to mass death of bamboo.

Threat on livelihoods

Threat outbreaks of invasive and shortage of food:

Reports evidenced that there is potential outbreak of rodents and other animals that savour on the abundance of bamboo seed after gregarious flowering (Ramanayake, 2006, Jeeva *et al*. 2009). These pests usually turn to cultivated crops after depletion or germination of the bamboo seeds causing devastation food crops leading to famine (John and Nadgauda, 2002; UNDP, 2008; Jeeva *et al*., 2009). The current lowland bamboo mass flowered areas in Benishangul region, Ethiopia which is majorly inhabited by pastoralists might be

immune to possible rodent explosion as there are less crops cultivated. However, the mass flowering of highland bamboo in Dawro zone, Southern region of Ethiopia seems potentially highly susceptible if the outbreak follows the bamboo seed set. The situation might even be more sever given that the zone is characterized by dense population and dominance of vegetables and maize cultivation (SNNPR Livelihood Profile, 2005) which are more vulnerable to rodent attacks (Parashad, 1999; Fayenuwo *et al*., 2007).

Potential economic impact:

Recently, bamboo based small and medium businesses are growing in Ethiopia. In most of areas, particularly, in highlands where it grows bamboo remain to be one of the major income generating commodities for local community (Statz et al. 2007). An increase in number of bamboo workshops in many cities, promised bamboo to be an important item having a paying price. Although it is in small amount, currently there also is export of bamboo in different forms (Adnew and Statz, 2007). The current mass flowering of bamboo might hence adversely affect the growing bamboo based businesses in Ethiopia. Earlier bamboo flowering shattered the hope of many local people who were relying on bamboo for their income generation and substantially affected the whole market (Statz et al 2007; Gebremariam et al., 2009). The current simultaneous mass flowering and death of both the highland and lowland bamboo might even worsen the situation and has potential cause of raw material scarcity in bamboo based workshop. The phenomena would be more discouraging to the Dawaro people who strongly are economically and culturally tied with bamboo.

Actions to combat the negative consequences of mass flowering

Conservation measure

Seed based conservations:

Against the many potential risks, bamboo mass flowering is a blessing phenomena to get a genetically diverse next generation via seed. As a result of the rare occurrence of bamboo seed setting, seeds are hardly available for most species for long time. Seeds also are easy to handle, transport and store. This makes processes easy particularly for *ex situ* conservation. Thus seedling raising and covering large areas out of the natural habitat can also be realized easily. Yet, *in situe* conservation, by allowing new seedlings to regenerate naturally need to be given priority and due attention. This requires protection of the bamboo mass death areas from animals, possible fire and other damages that may hamper regeneration. Seedlings from seed are more sensitive and demand more care than clones sprouting from well developed mature rhizomes.

Invitro propagation:

As all ex situ clonal materials are at possible verge of loss, invitro culture may help to retain materials. In response to the current mass flowering of bamboo, the Holetta Agricultural Research Centre, Biotechnology tissue culture lab has already commenced bamboo shoot initiations protocol and has reached promising set ups. Once the appropriate protocol is in place, the lab will further work for mass propagation to produce its maximum possible outputs to restore the possible bamboo losses. However, both local and federal government and non-government organizations need to be well oriented and able to support this endeavour for timely responses.

Population genetic structure analysis:

In order to set up a reliable conservation strategy, records of genetic variants harboured in at least major populations of bamboos in Ethiopia are required. Since bamboos are mostly multiplied clonally and since single plant can form huge population through time (Williams et al, 1995, Miyazaki et al, 2009) there might be deprivation of genetic variation with in a population (Wong, 2004). That might also be the reason, the whole individuals of a population flowers at a time (Miyazaki et al, 2009). In some Ethiopian highland populations, local people identify variants in a population. Among others, the highland bamboo populations in Awi

zone Enjibara district, Amhara regional state of Ethiopia are recognized by harbouring four locally identified variants. Unlike other bamboo populations, a yearly flowering patch at St. Johannes church compound might indicate the deviance in genetic composition of this population. In congruent to this argument Gagnon and Platt (2008) reported both mass flowering and single plant or small patch flowering of Arundinaria gigantea. The local communities in Dawro zone also recognize four variants of which one they claim less affected by flowering. The Berta people in Benishangul Gumuz also identify two variants. However, information is lacking to reach a conclusive statement to the foretasted claims. Therefore, genetic structure analysis of populations is recommended to at least partially unveil the enigmatic process of bamboo and enable to combat possible risks accordingly.

Habitat follow up and possible outbreak prevention-control

Awareness creation to local community:

Perhaps connected to the rareness of the bamboo flower phenomena, in many communities it is considered as indicator of bad fortune (John and Nadgauda, 2002; Ramanayake, 2006). In most bamboo growing areas, its flowering is regard as disease (Embaye, 2000). As a result the local communities are not aware of bamboo provides seed after flowering which they actually assume it a disease. Therefore, they do not try to collect and conserve seeds. Such lack of awareness was also observed when the bamboo researching team was visiting the Dawro flowered bamboo populations. Therefore, awareness creation is to be one of the actions in the process of avoiding the risks of bamboo mass flowering.

Field assessment in bamboo flowering areas and possible outbreak preventions:

In order to take timely and appropriate measure up on possible outbreaks of pests, there is a need to regular field assessment in the bamboo flowering areas. Removal of dead bamboos might help to reduce available food and shelters for pests like rodents. Such measure particularly is workable and advised to Dawro zone where bamboo is an integral part of the farming systems.

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