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Impact of African Traditional Termite Control Methods on Conservation of Biodiversity: A Review

Paulyne, A. Agutu[1] * Mary, C. Imbo[1], Timothy, O. Makori[2] and Richard K. Rotich[3]

[1]*School of Biological Sciences, Jomo Kenyatta University of Agriculture and Technology, P.O.Box, 62000-00200, Nairobi, Kenya*

[2]*Department of Horticulture, Faculty of Agriculture Jomo Kenyatta University of Agriculture and Technology, P.O.Box, 62000- 00200, Nairobi, Kenya*

[3]*Institute for Biotechnology Research, Jomo Kenyatta University of Agriculture and Technology, P.O.Box, 62000- 00200, Nairobi, Kenya*

Abstract

Termites cause a wide array of damages to plantations, trees and manmade structures. Both industrial and food crops as well as forest trees are attacked by termite. Reports on economic losses caused by termite infestations have been made worldwide. Consequently, need to eliminate and control termites have risen especially by farmers and property owners as a measure to secure their produce and property respectively. Poverty prevalence in Africa limits accessibility to chemical control methods which are expensive and requires expertise to use hence unaffordable. In response, African communities have devised and applied traditional methods in order to eliminate and or control termites in farmlands and homes. However, these methods have not been scientifically proven and the extent of their efficiency is still questionable. On the other hand, there is a feeling that these methods are environmentally friendly and safer for biodiversity conservation as compared to the conventional methods of termite control. In order to curb loss of biodiversity experienced globally sustainable methods of termite control should be employed. Usually this loss is accelerated by continuous clearing of natural vegetation to accommodate the ever growing population particularly in Africa. Depending on the methods used biodiversity can either be conserved or lost in the process. This review therefore explores the traditional uses of termites in Africa, elaborate on the common traditional methods used to control them. It also details the advantages of these methods over conventional methods on biodiversity and environmental conservation.

Key words: Termites, Biodiversity, Africa, Traditional

1. Introduction

Termites are a group of eusocial insects found across the world in countries with varied climate and land cover systems (Rahman *et al.,* 2013). They have been reported in all the continents of the world but Antarctica (Moawad *et al.,* 2015). Termites feed on wood and other materials that contain cellulose. However, they cannot independently digest cellulose, and majorly depend on the help of microbial communities in their gut system to do so (Ohkuma and Brune, 2011). The result of their feeding activity is damage to plantations and manmade structures as well as decomposition and modification of soil properties (Ulyshen, 2014). The soil modification further enhances the availability and even distribution of soil nutrients as well as improved water and air flow (Fall *et al.,* 2007). As a result termites have been termed as ecosystem engineers and pests of economic importance (Jouquet *et al,* 2006). Termites build different kinds of nest structures, the most prominent of them being their highly sophisticated mound structures (Peters *et al.,* 1996).

Since Africa is ranked as the top continent in terms of termite species richness with over 70% of all the identified species (Ahmed *et al.,* 2011), indigenous communities have immense knowledge of these insects and have improvised ways of identifying and controlling them.

2. General information on termites

Termites are small bodied lightly pigmented insects usually confused to be the white ants. They are phylogenetically related to cockroaches (Inward *et al.,* 2007). They belong to the order Isoptera under which there are seven families and fifteen subfamilies (Grohmann *et al.,* 2010). Latest classification by Engel et al.

(2011) lists over 3500 identified species of termites. They are prominent in both tropical and subtropical ecosystems (Kemabonta and Balogun, 2014). Termites are classified based on their feeding habits and habitats. Under feeding groups there are wood feeders, soil feeders and fungus cultivating termites (Kudo, 2009). Based on habitats they can be earth dwelling having below ground or epigeal nests, wood dwelling or arboreal having nest on trees. Many types of earth-dwelling termites exist, such as the subterranean termites and mound building termites. The wood-dwelling termites on the other hand, restrict themselves to wood. Wood-dwelling termites are further classified as either dry wood termites which attack dry wood, or damp wood termites attacking damp wood usually decaying wood (Kofoid, 1934). Termites exhibit a unique feature of caste system with reproductive division of labour among castes. A colony consists of three castes, a reproductive caste whose work is only to multiply the colony, soldiers who defend the colony and workers who do all the work of feeding and maintaining the habitat (Lefebvre *et al.,* 2008). The workers are therefore the greatest enemies of man's property causing damages in the process of their work.

3. Distribution of termites in Africa

Although termites are ubiquitous worldwide, Africa is the richest in the number of termite species known and identified (Mohammed *et al.,* 2014). The species richness is as a result of the friendly climatic conditions in Africa (Ahmed *et al.,* 2011). The family *Termitidae* alone comprises of more than 664 African species. There are four known subfamilies under this family and they are listed as *Apicotermitinae* having 70 species (Kanwal *et al.,* 2011), *Termitinae* with 272 African species (Eggleton, 2000). Macrotermitinae so far records 165 African fungus growing termites (Eggleton, 1999) whereas Nasutitermitinae boasts of 56 species (Mahaney *et al.,* 1999). The total number of species in the above subfamilies may surpass 90% of the world's known termite species (Ahmed *et al.,* 2011). Species diversity however varies within and between regions. For instance species diversity is lower in northern Africa compared to Eastern, Western and Southern region of the continent (Ahmed *et al.,* 2011). Dry climate has been cited as the contributing factor for the low number of species in the Northern region of Africa (Ahmed *et al.,* 2011).

4. Traditional uses of termites in Africa

It is not only in Africa that termites have found immense uses and applications. All the other continents but Antarctica where termites are found (Moawad *et al*., 2015) also find these insects to be of great value especially based on scientific research and findings (Ohkuma and Brune 2011; Gosling *et al.,* 2012). However knowledge that indigenous communities in Africa possess regarding the uses of termites do not have scientific base but rather depends on the mythical guidelines (Akutse *et al.,* 2012). This however does not mean that their knowledge is completely off-track as some of these information closely relate to scientific knowledge (Nyeko and Alubayo 2005; Nyukuri *et al.,* 2014). Moreover a huge number of scientific research work have borrowed a lot from the indigenous knowledge.

4.1 Beneficial uses of termites

In present times more knowledge on the economic importance of termites is publicly availed through rigorous research work and publications. However indigenous knowledge on uses and application of termites also exist within different countries. It is worthy to note that not in most instances indigenous applications agree with scientific information. The only difference is that with research developed countries have scientifically proven work

4.1.1 Termites as source of food in some African communities

For some time now FAO has been making calls to adopt insects as source of food (Niaba *et al.,* 2012). This has been accompanied by research attempting to find the amino acid and protein components of the insects and compare them with those from other sources as red meat and fish (Nyukuri *et al.,* 2014). Such reports show that termites are very nutritional. A typical example borrowed from the work of Nyukuri et al. (2014) in western Kenya is presented on Table 1. Earlier positive findings have been reported from various research works on the same boosting response to the calls by FAO (Mbah and Elekima, 2007).

However, the truth of the matter is that some communities from all over the world and especially Africa have been consuming termites for a number of decades. There is literature as early as in the 20th century showing insect consumption in Africa. Sileshi et al. (2008) lists a number of such reports.

The review (Sileshi *et al.,* 2009) list a number of communities that consume termites or use them as recipes for food preparation. Various countries in Africa are engaged in the use of termites as food and feed for their poultry. However there are some regional differences in the uses and consumption of termites depending on indigenous beliefs. For example there are some farmers in Uganda that reported some termite species as being poisonous and not good for consumption (Nyeko and Alubayo).

The fungus cultivating group of termites is famously known for the edible mushrooms they cultivate. They are very common in Africa and their presence is evident by the huge mound structures visible in most African terrains (Luke *et al.,* 2014). The mushroom species found growing on termite nests are consumed regularly in many tropical countries. Wild mushrooms constitute important food supplements for local populations and also have a role in cultural traditions (Srivastava and Pandey, 2012; Sileshi *et al.,* 2009). The habit of consuming termite mound soil by some women and children in Africa has also been noted (Ibrahim and Adebote, 2012).

4.1.2 Uses of termites as traditional medicinal components

Yoruba traditional doctors in Nigeria have been cited as using a number of *Termitomyces* species as medicines or charms. These mushrooms also have a place in mythical folklore (Sileshi *et al.,* 2008). Claims that termite are used as medicinal components should be investigated. We notice that in various resources it is only mentioned with no elaborate information (Sileshi *et al.,* 2009; Ibrahim and Adebote, 2012). Akutse et al. (2012) also reported some information on how the termite mound soil is used by some Ghanaian communities to treat boils. Their study also revealed the use of the queen and king termites for achieving healthy skin in children as well as curing wounds. Probably investigating the mechanism through which these are achieved and which parts of termites have medicinal properties would provide more insight into these claims.

4.1.3 Use of termite as seasonal indicators

In the past and even at present times African communities use termites as indicators of seasons and climate change. Occurrence of termites swarms for instance among other indicators predicts the early onset of rainfall. In Zimbabwe termites are used to predict climate change (Okonya and Kroschel, 2013). In a case study in Tanzania assessing the indigenous knowledge in seasonal rainfall prediction Termite species of the genus *Ancistrotermes* were listed among major indicators of near rainfall onset (Changa'a *et al.,* 2010). These are just but a few cases to mention in Africa.

4.1.4 Use of termite in soil improvement and agriculture

That termites are major decomposers that contribute to different ecological processes in the ecosystem which in turn improve soil properties in a positive way is no news to the scientific and agricultural world. For decades reports have been tripling in regarding ecosystem engineering properties of termites nearly from all the major continents; USA, Asia Australia north and south America and even Africa (Jessen, 2014; Gosling *et al.,* 2012; Jouquet *et al.,* 2006).

In the African set up farmers also have their indigenous knowledge on these properties and know how to utilize the benefits thereof (Mugerwa *et al.,* 2014, Akutse *et al.,* 2012). Take for example farmers in Ghana who believe that planting around the mounds improve their crop production (Akutse et al. 2012). Much as this remains just a belief to them scientific research by (Stoops and Schaefer, 2010; Abe *et al.,* 2009) confirm these allegations of termite mound soil being super rich in nutrients. Breaking of the old termite mounds and mixing the mound soil with the agricultural farm soil is a major practice in various African countries aimed at improving crop productivity such as coffee, sugarcane, sorghum, cassava, corn and some vegetable crops like (Cadet *et al.,* 2004; Andrikanja *et al.,* 2007; Sileshi *et al.,* 2008). West African farmers are especially known and believed to have been taking advantage of farmlands infested with termite mounds for fertility purposes (Ogedegbe and Ogwu, 2015).

4.2 Negative effects of termites

From the discussion on the positive impacts of termites and their tremendous uses one would easily wonder why the need to damage and eliminate them. However that is not the case as their negative implications are also countable hence raising serious concerns.

4.2.1 Pest properties of termites

Agricultural sustainability and food security is a major concern in Africa and any practices that can help achieve this like identification and control of termite pests that infest crop products are highly encouraged (Maayiem *et al.,* 2012). This notwithstanding the fact that environmental and biodiversity conservation also matters. Knowledge of pestiferous termites in Africa is wide and it is a major concern for many farmers in all the corners of the continent (Sileshi *et al.,* 2008). Indigenous knowledge on the pests indicates that not all species of termites are pests. Other scientific reports have also found that only a few species of all the known over 3500 of species are pestiferous. For instance in the year 2000, Pearce reported that less than 185 termite species were pestiferous. Of the known species in Africa less than 5% are pestiferous yet still many societies regard them as pests (Sileshi *et al.,* 2008). This is to say that a large majority of termites are not pests as commonly perceived. Knowledge of the individual species would be important in determining suitable control and management strategies for the specific pests. Investigations to differentiate pest species from non pest species would be necessary especially with the current available DNA techniques used for identification (Davies *et al.,* 2012). These DNA techniques allow the analysis of genetic markers and establish the identity of individuals (Garrick *et al.,* 2015). This way control efforts will only focus on the pest species an approach that will lead to biodiversity conservation (Sileshi *et al.,* 2008)).

A variety of crops have been reported to suffer severe attack by pestiferous termites. Since different countries grow different crops the variety is just amazing. Maayiem et al. (2012) observes that termites pose evident threats to both food and industrial crops. In Uganda farmers have reported termite attacks on crops such as maize and cassava. In Kenya reports on termites attacking coffee and vegetables are available (Mugerwa *et al.,* 2014). Malawi, Zambia Ghana Ethiopia are among the countries which have reported termite attacks on their crops (Mugerwa *et al.,* 2014). Termite infestation on agricultural farms leads to great losses in produce. The loss is not only detrimental to the farmers but to the economy of a country especially those that rely on Agriculture.

4.2.2 Damage to buildings and property

Cellulosic materials are the main sources of feed for termites. Damages arise as a result of the feeding activity of termite which is aided by the symbiotic microbes, bacteria and fungi capable of digesting cellulose (Ohkuma and Brune, 2011). Termite target structural timber in buildings and go even deeper into other things within the building such as furniture, clothing and books (Tagbor, 2009). There are some common genera that have been associated with destruction. These include *Coptotermes, Rhinotermes, Macrotermes, Odontotermes, Reticulitermes* and *Microtermes* (Su *et al.,* 2000). Some countries in Africa are able to table the losses they have incurred as a result of termite damage but generally losses due to termite damage worldwide runs into billions of US dollars (Ye *et al.,* 2004).

5. Common termite control methods practiced in Africa

A number of publication on termite control (Mugerwa *et al.,* 2014; Akutse *et al.,* 2012) give methods applied to control termites in farms and in buildings. Management and control strategies of termite per continent also varies (UNEP, 2000). For the traditional methods used in Africa some are limited to certain countries depending on indigenous understanding while majority are ubiquitous across the continent. A review by a group of individuals (UNEP, 2000) urges the use of these traditional control methods as alternatives to the chemical control methods rather than looking upon them as non-scientific based. Moreover, traditional methods are simple to follow and conduct and cost effective especially in the African setup. Sileshi et al. (2008), however, argues that the use of traditional methods should be complemented with the conventional methods to achieve great results. One thing that farmers and other property owners should bear in mind is that termites only become destructive in the process of performing their ecological roles and particularly when there is no other source of food for them and that with such provisions their attack would minimize (Ogedegbe and Ogwu, 2015).

5.1 Termite control methods with minimal effects on biodiversity

Methods such as intercropping, crop rotation, planting resistant crops among others are among some of the most encouraged traditional methods as they have no or very little effect on environment and biodiversity composition (UNEP, 200). Intercropping involves planting crops that are resistant to termites together with the susceptible ones. Termites have the ability to achieve pest status in agroforestry which can be curbed by intercropping (UNEP, 2000). Crop rotation in small scale farming works out best for termite control. This means the same crop especially the susceptible ones should not successively follow each other but rather rotated with the resistant or repellant plants. This method has been used in western African countries as well as in Ethiopia where some

grasses are rotated with the other crops (Mugerwa *et al.,* 2014). Since termite communities are not targeted directly impact on the communities is not rampant. Another method which has minimum impact on biodiversity is use of plant materials either as mulch that act as alternative food material. This material is always put in one spot away from the farm (Mugerwa *et al.,* 2014). Certain plant extracts (varies within countries) are used to deter termite activities (Sileshi *et al.,* 2008). Just like intercropping the method does not involve use of chemicals unless the extracts are further investigated to find the components responsible for the repulsiveness and whether they could be poisonous. Until then it will remain recommendable for conservation of environment as well as biodiversity conservation. Human urine and dung of either goats or cow has been used by some communities in Kenya (Malaret and Ngoru, 1989) to control termites. Dung works by acting as alternative food for termites. It can be applied on fence posts or heaped in one part of the farm. Apart from attracting termites to the spot the dung also acts as manure and enriches the soil (Nkunika, 1998). Alternatively the manure increases the activity and survival of termite predators. As a result the biodiversity is enhanced (Mugerwa *et al.,* 2014).

5.2 Termite control methods that could negatively impact on biodiversity.

The most common method observed is the destruction of termite nests (Akutse *et al.,* 2012; Mugerwa *et al.,* 2014) as termites are known to build epigeous mounds which affects cultivation and farm preparation (Ibrahim and Adebote, 2012). This involves breaking and digging out the mound in order to reach and kill or remove the reproductive queen and king of the colony (Mugerwa *et al.,* 2014). Studies argue that this method is not effective as comeback of the termites after a period of time is experienced. Although this comeback is only achieved by some groups that are capable of grooming new queen and king (*Cubitermes, Macrotermes*) as suggested by Mugerwa et al. (2014) some groups cannot do this and in such cases the biodiversity is likely to be affected. Alternatively this method involves the use of synthetic chemicals to destroy the colonies (Nyeko and Olubayo 2005). Such chemicals may in turn affect the environment and biological communities that they habour (Mugerwa *et al.,* 2014). Other methods that could be categorized as harmful to the termite species and environment are use of fire and smoke, wood ash, hot water mixed with pepper treatment (Mugerwa et al 2014). First, their mechanism of action is not clear, quantities applicable are not constant as reported by farmers in a study on Uganda (Nyeko and Alubayo, 2005). Moreover some of them like fires seem not only detrimental to the termite communities but also on nearby vegetation and organisms (Mugerwa *et al.,* 2014). Such practices should therefore be investigated to determine effects they pose on biodiversity.

6. Conclusion

Beneficial aspects of termites are overwhelming enough to guarantee their maximum conservation. However losses due to termite damage are also of concern to the society at large. Use of traditional methods to control termites is not a new thing in Africa and even some Asian countries. The same way Africa is perceived to be rich in termites so is it rich in the traditional control strategies which cannot be overlooked as just lacking scientific base. It is also agreed that that most traditional control methods are effective and affordable. However, the mechanisms by which some of these methods work are unclear and only need to be ascertained. Those whose mechanisms of destruction are clear like cultural agricultural practices are worth implementation as they contribute a lot to the conservation of environment as well as biodiversity. However before the implementation take place there is need to investigate some critical claims that have been associated with some of the methods like intercropping with tolerant plants. The review noted that these methods are no targeted to specific species due to the limited knowledge on the termite pest species. It would therefore be a great idea to get the limited knowledge on pestiferous termites by the various indigenous groups, incorporate it with the scientific knowledge and avail the information to these groups. To do this more work on identification of termites regionally should be enhanced to provide more termite inventories. Additionally, the potential of tolerant, repellant and resistant plants for termite control should be explored extensively and incorporated in the other control strategies. This way termite management and biodiversity conservation will both be achieved. Moreover the indigenous knowledge would have also been tapped for a better course. Finally and of most importance for the non-pest termite species to effectively and maximally play their ecological roles and to be fully conserved, ecologically friendly termite control methods are encouraged. Conservation of other species other than termites that could have suffered collateral damage are protected in the process.

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Table 1. Protein constituents in termites, fish and red meat compared (Nyukuri *et al.,* 2014).

Ingredients (% as fed basis)	*Food items*			ANOVA	
	White ant	Tilapia fish	Red meat	F-value	*p-value*
Moisture	70.2 ±	69.6 ± 1.21	68.21 ± 1.02	0.432	0.532
Crude protein	63.9 ±	56.9 ± 1.76^{c}	52.22 ± 1.32^{b}	5.42	0.004
Crude lipid	9.35 ±	5.54 ± 1.04^{a}	6.23 ± 1.07^{a}	9.785	0.000
Crude fiber	9.53 ±	8.27 ± 2.22	10.24 ± 2.94	1.954	0.094
Gross energy (kcal 100 g^{-1})	4.99 ±	4.53 ± 0.23	4.43 ± 0.24	1.562	0.234
Essential Amino acids (g 100g^{-1})					
Histidine	4.02	3.95	2.25		
Isoleucine	2.56	2.98	3.31		
Leucine	4.36	2.64	3.41		
Lysine	5.79	5.21	5.04		
Methionine	3.78	3.56	3.51		
Phenylalanine	4.91	5.39	4.92		
Threonine	4.64	4.01	4.22		
Valine	3.32	3.87	3.99		
Total EAA	31.5	30.6	30.1		
Ratio:EAA:CP	46.8	46.0	46.2		