Agricultural Research & Extension Network

AgREN

Network Paper No. 143
January 2005

PARTICIPATORY ASSESSMENT OF FARMERS' EXPERIENCES OF TERMITE PROBLEMS IN AGROFORESTRY IN TORORO DISTRICT, UGANDA

Philip Nyeko and Florence M. Olubayo

Abstract

As agroforestry technologies are developed and promoted, there is a need to integrate indigenous knowledge about pest identification and management techniques into the scaling-up process in order to improve farmers' pest management practices. This paper documents farmers' knowledge, perceptions and management practices against termites in agroforestry in Tororo District, Uganda. The applicability and implications of such information in the development and promotion of sustainable termite management in agroforestry are discussed.

Research findings

- *Farmers have a deep understanding of the diversity, abundance and distribution of termites in their villages. Simple features such as mound building character, mound morphology, timing of alate flights, and size, colour and/or odour of workers, soldiers and alates are effective indigenous termite identifying characteristics.*
- *Termite damage is the most limiting constraint in tree cultivation in Tororo District, but some termite species are important food sources. Other highly rated problems in tree growing include lack of planting materials, drought and attacks by moles and defoliating caterpillars.*
- Macrotermes bellicosus *and* M. subhyalinus *are considered the most abundant termite species in Tororo District, attacking the widest range of trees and crops, and causing the most damage. However, the farmers know some tree species and crops which are not attacked by any termite species.*
- *Farmers have attempted several termite control methods, including application of plant extracts, cow and human urine, heat and/or smoke, dead animals, chemical pesticides and the physical removal of the queen or destruction of the mound. However most of them lack knowledge of these methods of control or the skills to apply them properly, and they consider this to be their most important constraint in managing the termite problem.*

Policy implications

- *Termite damage in agroforestry is an important issue demanding concerted efforts and resources to develop new management approaches that build on, rather than destroy or ignore, farmers' indigenous knowledge and practices.*
- *Indigenous pest identification and control practices in agroforestry need to be documented, verified, standardised, adapted and promoted to farmers with other integrated pest management (IPM) measures with the aim of reducing the application of chemical pesticides.*
- *Mechanisms are needed to train farmers and encourage farmer-to-farmer transfer of appropriate pest management information. The farmers' field school approach and community advisory concept could be excellent ways for agencies promoting agroforestry to generate and spread IPM information.*

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The Agricultural Research and Extension Network is sponsored by the UK Department for International Development (DFID). The opinions expressed in this paper do not necessarily reflect those of DFID.

Network Coordinator: Robert Tripp   Administrative Editor: Alana Coyle

ISBN 0 85003 744 1

Acknowledgements

This study was sponsored by the International Centre for Research in Agroforestry (ICRAF), Nairobi under the Small Grants Scheme. Additional support was obtained from the Royal Museum for Central Africa (RMCA), Belgium and the Association of African Universities (AAU). The authors are grateful to Professors J. Ruelle, J. Deligne and Dr. E. DeConninck for assisting in the identification of termite samples. S. Franzel, E. Coe, G. Nyamasio, E.O. Obudho and P. Mongare provided very useful comments on drafts of this paper. We gratefully acknowledge J. Ogwang for providing technical assistance and actively mobilising farmers during our fieldwork, and the farmers for their active participation in this study.

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Acronyms and abbreviations

AAU	Association of African Universities
FORRI	Forestry Resources Research Institute, Uganda
ICRAF	International Centre for Research in Agroforestry, Nairobi
IPM	Integrated Pest Management
LC	Local Council
NEMA	National Environment Management Authority
NGO	Non-Governmental Organisation
PMA	Plan for Modernisation of Agriculture
PRA	Participatory Rural Appraisal
RMCA	Royal Museum for Central Africa, Tervuren, Belgium

PARTICIPATORY ASSESSMENT OF FARMERS' EXPERIENCES OF TERMITE PROBLEMS IN AGROFORESTRY IN TORORO DISTRICT, UGANDA

1 INTRODUCTION

The literature on smallholder agricultural development emphasises the need for research institutions to understand indigenous knowledge systems in a bid to adapt their technologies to local farmers' situations in order to enhance the acceptance and adoption of these technologies (Chitere and Omolo, 1993; Norton et al., 1999). However, there continues to be very little information on farmers' perceptions of pests, management practices and decision-making processes in agroforestry. As agroforestry technologies are developed and promoted, there is a need to integrate indigenous knowledge about pest identification and management techniques into the scaling-up process in order to improve farmers' pest management practices (Nyeko et al., 2004).

Agroforestry has been defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (Leakey, 1996). It is regarded as an effective, low-cost means of minimising the degradation of cultivated land and of maintaining or even increasing the productive capacity of agricultural ecosystems (Chuntanaparb and MacDicken, 1991). In Uganda, agroforestry is one of the key components of national policy for poverty alleviation and rural development through the Plan for Modernisation of Agriculture (PMA). The current Uganda forest policy also encourages farmers to grow and protect their own trees to meet the increasing demand for tree products and services. Trees growing on agricultural and natural land play a crucial role in Uganda's national economy, both in satisfying energy and industrial product needs, and in providing essential environmental services that support the country's agriculture, sustain its water supply and protect the soil (Howard, 1991).

Since 1988 agroforestry research in Uganda has focused on identifying tree species that can be incorporated on agricultural land without significantly interfering with food crops. Several agroforestry technologies have been introduced and promoted in the country, mainly by the International Centre for Research in Agroforestry (ICRAF) and the Uganda Forestry Resources Research Institute (FORRI) in collaboration with a number of non-governmental organisations (NGOs). Technologies for soil fertility improvement, production of fuelwood, timber, fodder, fruits and other products are being tested on both research stations and farmers' fields in several districts in the country. Many of the agroforestry activities have been targeted in areas with very severe land degradation, including the southern and eastern highlands, the Lake Victoria Crescent, south-western rangelands and the eastern lowlands.

However, the adoption of agroforestry technologies in Uganda is still modest in scale (Nyeko et al., 2004), and this situation is known to exist in all tropical countries (Nair, 1997). One of the main challenges in scaling up the adoption of agroforestry technologies pertains to the increasing emergence of new pests and diseases as well as the escalation of some previously known ones (Rao et al., 2000; Schroth et al., 2000). Thus plant health is an important issue which demands more attention if efforts to improve rural development and alleviate poverty through agroforestry are to succeed (Boa and Bentley, 1998). In a recent (December 2002) agroforestry review and planning workshop organised by FORRI in Mbale District for eastern Uganda, it became apparent that the issue of termite damage in agroforestry and the general environment is widespread and severe in the region. Participants of this workshop repeatedly raised it as a serious constraint to crop, tree and pasture production in the region. Such pest infestations can be frustrating to individuals and agencies promoting agroforestry technologies.

Termites have long been recognised as important agricultural and domestic pests (Logan et al., 1990). They are one of the major agroforestry pests in the tropics (Wardell, 1987). In Uganda, losses of crop and tree stands ranging from 50 to 100% have been attributed to termite attack (Sekamatte, 2001a). In a survey conducted in Nakasongola District, central Uganda, Sekamatte (2001b) recorded 10 pestiferous termite genera in farmlands and rangelands, including *Ancistrotermes, Allodontotermes, Armitermes, Cubitermes, Hodotermes, Macrotermes*, *Microtermes, Microhodotermes, Odontotermes,* and *Pseudacanthotermes*. This list is apparently not exhaustive since limited studies have been conducted to document pestiferous termites in Uganda. To date no publication apparently exists on damaging termite species on farmlands in eastern Uganda. This information is essential in developing management strategies against termites since not all termite species are pestiferous (Cowie et al., 1989).

Control of termites has largely relied on broad-spectrum and persistent organochlorine insecticides (Logan et al., 1990). However, serious limitations and increasing legal restrictions associated with the application and efficacy of these chemicals (Cowie et al., 1989; Logan et al., 1990) emphasise the need for alternative methods. Most non-chemical control of termites on farmlands revolve around good silvicultural or agronomic practices, physical destruction of termite mounds, biological control, and use of plant extracts and resistant species (Wardell, 1987; Logan et al., 1990). However none of these methods has been evaluated rigorously in agroforestry and their efficacy remains speculative. A key area that has yet to be adequately addressed in termite management is indigenous knowledge accumulated by local communities. Such information is essential for priority setting and also for development of pest management strategies that meet local aspirations and are thus likely to be adopted by local communities (Chitere and Omolo, 1993; Nyeko et al., 2002).

This paper examines farmers' indigenous knowledge of termites with the aim of developing and promoting integrated termite management in agroforestry. The paper specifically documents the following information about termites: (i) farmers' perceptions of termite damage in relation to other problems in agroforestry; (ii) their knowledge of the diversity and distribution of termite species; (iii) the perceived levels of termite damage on different agroforestry tree species and crops; and (iv) the termite control practices they have attempted and constraints encountered.

2 MATERIALS AND METHODS

Study area

This study was conducted in Tororo District, eastern Uganda, from September to December 2003. Tororo was selected because it is one of the target districts for agroforestry development in eastern Uganda where high levels of concern have been expressed regarding termite infestations. The district is located in the dry sub-humid lowlands in eastern Uganda. It receives 900–1300 mm bimodal rainfall with peaks in April and October on sandy loam soils of medium to low fertility. The longer of the dry seasons is from December to March. Mean annual temperature ranges from 20–30°C. The vegetation is short grassland with scattered trees. Environmental degradation is a growing concern in the district. Interrelated problems, including loss of biodiversity, insufficient supply of tree products and services, land degradation, soil erosion, decreased soil fertility and reduction in crop yields, are evident in many places around the district (National Environment Management Authority (NEMA), 1998). For example, the women spend up to 50% of their daily time fetching firewood for their families (NEMA, 1998), which is a serious misuse of their resources. This burden of household chores also affects the girls, as they are pulled out of school to help with domestic and farm work.

The staple food crops in the district are cassava, millet, maize and sorghum. In addition there are oil seed crops such as groundnuts, sesame and sunflower. Beans and cowpeas are also common. The main livestock kept include cattle, goats, sheep, pigs and poultry (chickens, turkeys and ducks). Agroforestry activities in the district are spearheaded by FORRI in collaboration with several NGOs. The major activities include researching and disseminating agroforestry technologies involving wood production, soil fertility enhancement, high value tree products (medicine and fruits) and fodder production. To this end, several exotic and indigenous tree species are being promoted in the district.

Methods

A total of 10 villages in three counties were selected for this study. These included Katarema C, Olobai, Asinget A, Morkiswa and Morgwang in Kisoko County; Kagwara, Aburi and Abongit in West Budama County; and Amagoro B and Osukuru Corner in Tororo County. Each village comprised of farmers belonging to the same local council (LC) I leadership. The villages were randomly selected, using a list of those villages in the district that had implemented agroforestry technologies. The list was obtained from FORRI, Tororo.

A participatory rural appraisal (PRA) approach was used in the study. Prior to fieldwork being carried out, the researchers met and briefed the LC I chairman of each village on the purpose of the study. The chairman was then requested to invite agroforestry farmers in the village to a PRA meeting on a date deemed convenient for both researchers and farmers. The study commenced with consultative and preliminary PRA meetings, which were held with farmers in two villages, Katarema C and Olobai, to focus the study. This resulted in the main study being carried out in eight rather than the 10 originally envisaged. Thus Katarema C and Olobai were excluded in the main phase of the study. During the consultative meetings, local termite experts in the villages were identified. Field excursions were then conducted with the local experts to sample the termite species reported in the villages for use as reference material during the study. The local experts were asked to identify the samples, giving their distinguishing features. The identities of the specimens were then confirmed in the PRA meetings. Authoritative identification of the termite specimens was done by the Royal Museum for Central Africa at Tervuren, Belgium.

In the main study, one PRA meeting was conducted in each of the eight villages selected for the study. Prior to each of these meetings, leaf samples of some tree species were collected either from on-farm trials set up by FORRI or from farmers' fields in the village. These were used at the PRA meetings to identify tree species whose names were not familiar to some of the farmers. The PRA meetings focused mainly on:

- general problems farmers had experienced with growing trees on their farms, in order to elicit their rating of termites as a constraint to agroforestry;
- diversity, abundance and topographic distribution of termites;
- termite damage to trees and crops;
- termites as a source of food; and
- termite control practices and constraints.

At the beginning of every PRA meeting, the participants were asked to register their presence, indicating their name, sex, ethnicity and highest level of formal education. The researchers began by introducing themselves and stating the purpose of the meeting, which was to generate information on problems affecting the cultivation of trees on their farms. They avoided mentioning termites at the outset of the meeting, not only to generate information on general problems affecting tree cultivation, but also to elicit the farmers' perceptions of termite damage in relation to other problems without biasing their responses. After the farmers had listed and ranked their main problems in tree cultivation, the researchers then explained that the meeting could not address all these matters in detail, but would focus on termites.

The *bao* game and a flipchart were used to quantify the farmers' rating of several variables, including:

- problems with growing trees;
- abundance and topographic distribution of termites;
- termite damage to trees and crops;
- patterns of rainfall and termite damage;
- termites as food;
- priority termite species for control; and
- farmers' constraints in termite control.

The *bao* game board (locally called Omweso or Choro in Tororo) consists of a piece of wood in which hollows have been carved. The board used in this study had a total of 32 hollows laid in a 8 x 4 matrix. The bao game is wholly mathematical with set rules. Two players, each entitled to 16 hollows play at a time. The players move seeds between the hollows, according to the rules of the game, until one of the players (defeated player) is devoid of all his/her entitled seeds. This marks the end of the set, and the players either start another set or the defeated player leaves room for another player. According to Franzel (2004), the game facilitates the collection of quantitative data in a manner that encourages the farmers' active participation and benefits them.

The farmers were encouraged to discuss and identify the critical points for each variable before the rating exercise. The points generated during the discussions were noted on a flipchart to aid the process. For example, after the points had been noted and the farmers had agreed which termite species they had in their village, they were asked to rank, on a *bao* game board, the topographic distribution of the termite species (lowland/valley, mid-slope, upland) as none, low, moderate or high. They did this by placing none, one, two or three seeds as appropriate in the corresponding hollows of the board. Similarly, they rated the levels of damage caused by each termite species to every tree species and crop reported in the meeting:

- no seed for no damage;
- one seed for low or minor damage (mostly dead bark with less than 10% mortality);
- two for moderate damage (between 10–50% tree/crop mortality);
- three for high damage (between 50–75% tree/crop mortality); and
- four for very high damage (more than 75% tree/crop mortality).

To determine what experiences the farmers had of seasonal variations in both rainfall and termite damage to trees and crops, they were asked to rate each of these variables on a scale of 0–10 for the months of January through December. To facilitate discussion the researchers guided the farmers to construct histograms from their rainfall and termite damage data on a flipchart.

At the various PRA meetings, the farmers discussed and agreed on each rating as a group. This approach saved time and allowed the farmers to have a thorough discussion before unanimously agreeing a rating. However, in evaluating termites as a food source, males and females rated their preferences separately because only males collected alates (winged reproductives commonly called 'white ants') of some termite species. When it came to termite control, farmers who had attempted this were identified by a show of hands. They were each asked: (i) what control methods (materials) they had attempted, (ii) how they applied them, (iii) on which termite species the control had been attempted, and (iv) how effective the control method had been. For this last they used a scale ranging from ineffective, through slightly effective and moderately effective to highly effective.

Data analysis

Quantitative data from the eight villages were analysed using the Minitab statistical package. The quantitative data generated during the preliminary PRA meetings in the two villages were not analysed for presentation in this paper because the study was refocused after the preliminary phase. Farmers' ranks of the different variables were converted to scores. For example, ranks of 1, 2, 3, up to 10 were converted into scores of 10, 9, 8, etc. Details of the conversions for each variable are presented in the relevant tables in Section 3. Mean scores for each of the variables were determined, by averaging the scores from the different PRA meetings, using descriptive statistics. Qualitative information generated during the study is summarised and presented in Section 3.

3 RESULTS

Farmers' profiles

Overall, 246 farmers from eight villages participated in the eight PRA meetings, with attendance ranging from 10 to 49 individuals per meeting. When considered across the villages, roughly equal numbers of men (52%) and women (48%) attended. However, women were in the majority in Morgwang (84%), Morkiswa

Table 1 Farmers' rating of their main problems with tree cultivation

Problems	Number of villages affected	Mean score
Termites	8	17.0
Moles	5	16.8
Lack of seeds/seedlings	8	16.8
Defoliating caterpillars	8	14.3
Drought	8	14.1
Lack of knowledge and skills	2	12.5
Damage by livestock	8	12.5
Limited land	2	12.0
Negligence in management	7	11.4
Fruit pests and diseases	1	11.0
Strong wind	8	10.9
Vandals (malicious damage)	8	10.6
Rocky sites	5	10.0
Weeds	1	10.0
Fire	6	9.3
Soil erosion	1	8.0
Flood (excess rainfall)	2	7.5
Low soil fertility	1	7.0

Ranks 1, 2, 3, … 18 were converted to scores as 18, 17, 16…1 respectively.

(74%) and Abongit (62%), which had active women farmers' groups. The farmers' age averaged 37 years, but varied markedly from 14 to 72 years. The 14-year-old participant possibly represented the parents or was a worker on someone's farm, as this age seems too low for a farmer. The majority (47%) of farmers were middle-aged (31–50 years) and only 18% of them were above 50 years old. Most farmers (79%) had some formal education, with equal proportions (39%) claiming to have stopped in primary or secondary school. There was only one diploma holder and no university graduates. Several ethnic groups were represented, the majority of whom were the Japadhola (58%) followed by the Itesot (35%). The others (7%), mostly women married to the Japadhola and the Itesot, were the Basoga, Modama, Langi, Banyoro, Bakiga, Bagwere, Bagishu, Basamia and Munyole. Despite this ethnic diversity, all the farmers could speak Japadhola fluently, hence all the meetings were conducted in this language.

Problems with growing trees

Farmers identified 18 major problems with growing trees (Table 1). Damage caused by termites, defoliating caterpillars, drought, livestock, wind and vandals, and lack of planting materials (seed and seedlings) were common to all the villages. In contrast, fruit pests and diseases, weeds, soil erosion, lack of knowledge and skills for on-farm tree cultivation, limited land and flood were rarely reported and generally had low ratings. On average, farmers rated termites as the most serious problem, followed by moles and lack of planting material. Although damage by moles was highly rated, it did not occur in some villages (Morkiswa, Morgwang and Abongit), indicating patchy distribution of the pest.

Diversity, abundance and distribution of termites

Farmers identified all the termites encountered during the study by their local (Japadhola) names. A total of 14 termite species were identified in the local language, and these were markedly consistent with scientific identifications (Tables 2 and 3). Farmers' identification of termites was based on a number of characteristics. These included: (i) mound building (ii) size of mound (iii) presence or absence of vents on mounds (iv) size, colour, odour and taste of alates (winged reproductives), soldiers or workers (v) seasonal and diurnal flight periods of alates (Table 3).

The majority of the termite species occurred in all the villages, except Ogwee, Mbala and Sisi (Table 2). Ogwee was reportedly absent in Aburi while Sisi was absent in Abongit, as was Mbala in Aburi, Osukuru Corner and Abongit. The most abundant termite species was Ripo followed by Agoro, Magere and Wambwe, but Majiji and Mbala were generally very scarce (Table 2). Farmers' rating of the topographic distribution of the different termite species varied markedly between the species (Table 3). For example, whereas some species were rated as most abundant upland and very rare (or in some villages, absent) in valleys, the reverse was true for other species.

Table 2 Farmers' rating of the abundance and topographic distribution of termites in Tororo District

Termite species	No. of villages	Abundance (mean score)	Distribution (mean score)		
			Valley	Midslope	Upland
Ripo	8	13.1	0.9	2.0	3.0
Agoro	8	12.8	3.0	2.6	2.4
Magere	8	11.1	2.8	1.9	1.6
Wambwe	8	11.1	0.4	2.6	2.9
Rudho	8	9.0	1.2	1.9	2.6
Ogwee	7	8.7	3.0	1.6	1.1
Aming	8	8.6	2.3	2.5	3.0
Sisi	7	8.1	0.9	2.2	2.3
Singiri	8	7.4	2.4	1.3	1.1
Kithea	8	5.0	2.8	1.6	1.1
Thuk	8	4.9	2.6	1.5	1.3
Miyal	8	4.8	2.3	1.4	1.4
Majiji	8	2.3	2.6	1.4	0.9
Mbala	5	2.2	0.4	2.2	1.8

Termite abundance ranks 1, 2, 3, ...14 were converted to scores as 14, 13, 12,...1 respectively. Termite distribution was rated as 0, 1, 2 and 3 for none, moderate and high respectively.

Termites as pests in agroforestry

Tree damage

Overall, farmers reported eight tree-damaging termite species. These were: Agoro (*M. subhyalinus*), Ripo (*M. bellicosus*), Wambwe (*Pseudacanthotermes* species), Sisi (*P. militaris*), Magere (*O. kibarensis*), Singiri (*O. latricius*), Ogwee (*Odontotermes* species 1) and Rudho (*A. truncatidens*) (Table 4). However, Singiri was mentioned as damaging to trees only in Morkiswa, and Rudho was known to damage trees only in Osukuru Corner and Abongit. Farmers in the other villages considered Rudho as damaging only to dried plant materials, especially building materials and stored agricultural products. Farmers rated Ripo as the most damaging termite species. All tree species attacked by Ripo were also reported to be attacked by Agoro, with the exception of *Leucaena* species which farmers in Amagoro B claimed was highly damaged by Ripo and Magere. Damage by the other termite species was generally rated as minor or moderate, except for Rudho and Ogwee, reported as very highly damaging on *Grevillea robusta* in Osukuru Corner and Abongit.

Eucalyptus species and *Grevillea robusta* were reported as particularly highly susceptible to Ripo and Agoro. Tree species reported as completely free of termite attack in all the villages included *Thivolia* species, *Carica papaya, Milicia excelsa, Euphorbia candelabrum, Kigelia aethiopica, calliandra calothyrsus, Borassus aethiopum, Diospyros mespiliformis, Phoenix reclinata, Strychnos innocua, Securidaca longipedunculata, Citrus reticulata, Cupressus lusitanica, Tephrosia vogelii*, *Sesbania sesban* and cashew nut. These species were considered to be too bitter (poisonous), hard or 'milky' for termites. *Ficus natalensis, F. gnaphalocarpa* and another *Ficus* species (Raboki) were reported to be susceptible to termites only in Morkiswa and Aburi. Farmers in the other villages considered these *Ficus* species too 'milky' and thus unpalatable to termites. One farmer, in

Table 3 Farmers' identification of termite types in Tororo District

Termite species	Main characteristics
'Agoro' *Macrotermes subhyalinus* (Rambur)	Builds big mounds without vents. Alates are dark brown and are the largest of all types of alate. Alates swarm in April, between 8 pm – 3 am. Soldiers and workers have no distinctive odour. Two types of soldier and one type of worker (referred to as females by the farmers). Has largest of all the soldiers with red head, medium-size soldiers with red head and small females with dark brown heads.
'Aming' *Basidentitermes* (?*aurivilii* Sjöstedt) *Cubitermes ugandensis* Fuller	Two types: upland type, which does not build mounds (*B. aurivilii*) and has brown alates; lowland type which builds small mounds (*C. ugandensis*) and has black alates. Alates generally come out throughout the wet season. The brown alates emerge in the evening (between 5 and 6 pm), but the black type comes out between 12 noon and 6 pm. Alates are generally small: the brown type is sweet but the black one is bitter.
'Kithea' *Microcerotermes* species	Builds small mounds without vents and much of the mound is underground. Soldiers and workers generally small and whitish. Some soldiers have brown heads. Soldiers and workers are moderately bitter, but are popular feed for turkeys. Does not produce alates.
'Magrere' *Odontotermes kibarensis* (Fuller)	Doesn't build mound, but usually makes holes (vents) around tree base. Two types of alates: brown type for those found upland and a dark type for those located in lowlands (valleys). Alates swarm in April around 8 pm. Soldiers are of two types: medium-sized ones with red heads and small ones with brown heads. Soldiers produce a smell similar to Ripo and are bitter.
'Majiji' (Unidentified)	Doesn't build mounds. Alates black, medium-sized with broad abdomen. Alates swarm in April at around 2 pm. Soldiers are small and 'kind' (don't bite).
'Mbala' *Odontotermes* sp. 2	Doesn't build mounds, but forms circular patches on the ground with small vents in the middle of the patch. Alates are medium-sized and brown. Alates swarm in April at any time of the day. Workers small with dark brown heads. Soldiers medium-size with brown heads and white abdomen. No distinctive odour.
'Miyal' *Pseudacanthotermes spiniger* (Sjöstedt)	Builds medium-sized mounds (usually less than 1 m tall) without vents. Two types of alates: dark brown ones from upland and very dark ones from valleys. Alates swarm in August at any time of the day, though mostly in the evenings, as long as sufficient water is poured on the mound and the mound covered with grass or clothes. Dark medium-sized soldiers with brown head and dark small workers. Soldiers, workers and alates are generally sour.
'Ogwee' *Odontotermes* sp. 1	Builds nests with only ventilation shafts protruding above ground level. Alates medium-sized and dark brown. Alates swarm from March to June at any time of the day (but not in hot sunshine) when rainfall is simulated by beating pieces of wood on the nest. Alates and soldiers are generally dark-brown and are sweet. Soldiers have red heads. Workers are small with dark brown heads.
'Ripo' *Macrotermes bellicosus* (Smeathman)	Builds big mounds with large vents round the base of the mound. Alates medium-sized and dark-brown. Alates swarm from February to March between 5 and 7 am, following the onset of the first rainy season. Two types of soldiers as for Agoro, but generally smaller than the latter. Workers medium-sized with dark brown heads. Soldiers are very aggressive and their bites very painful. The soldiers produce characteristically 'sharp' smell when rubbed between thumb and first finger, and are bitter. The alates are generally sour.
'Rudho' *Amitermes* (? *truncatidens* Sands)	Builds small black mounds without holes, and is common in houses and granaries. Soldiers have black abdomens and red heads, and workers have black heads and white abdomens. Soldiers produce characteristically foul smell.
'Singiri' *Odontotermes* (?*latricius* Haviland)	Doesn't build mound. Alates swarm from bare ground (e.g. along road/path sides) in September usually around midday, especially during bright sunshine. Alates easy to lure out when some noise is made around the exit points (children usually sing songs for this purpose). White soldiers and workers are all dark. Doesn't produce any distinct odour.
'Sisi' *Pseudacanthotermes militaris* (Hagen)	Doesn't build mound. Alates medium-sized and dark. Alates swarm from 1 to 3 pm between September and December, depending on availability of rainfall. Two types of soldiers: medium-sized with red heads and small dark ones. Workers dark with swollen abdomen.
'Thuk' *Trinervitermes oeconomus* (Trägärdh)	Builds small dark mounds without vents. Two types of small alates (white and dark) which swarm in April between 4 and 6 pm. Workers are dark with lots of soil in the abdomen. Soldiers have brown heads. Soldiers and workers are bitter.
'Wambwe' *Pseudacanthotermes* species	Doesn't build mound. Alates mediumsized and brown. Alates swarm throughout rainy seasons, usually between 5 and 6 pm whenever it rains. Two types of soldiers as for Sisi. Soldiers, workers and alates are sweet.

The words in inverted commas are the Japadhola names of termites

Table 4 Farmers' rating of termite damage to tree species

Tree species Scientific name	Local name	Agoro	Ripo	Mean damage score* Magere	Wambwe	Sisi	Singiri	Ogwee	Rudho
Acacia hockii	Oryang	2.0	2.1	1.2	1.1	0.3	1.0	1.0	0.0
Acacia sp.	Mugangwe	2.3	2.3	1.7	1.3	0.0	1.0	1.0	-
Albizia coriria	Oberi	1.3	1.0	0.7	0.3	0.0	0.0	0.0	0.0
Artocarpus heterophyllus	Fene	1.6	2.3	1.1	0.7	1.3	2.0	0.7	0.0
Azadirachta indica	Neem	1.2	1.2	0.8	0.7	0.5	2.0	0.5	0.0
Casuarina sp.	Lwiyo	1.0	2.0	1.3	2.0	0.0	-	4.0	2.0
Citrus sp.	Muchungwa	1.4	2.0	0.7	0.5	2.0	1.0	0.3	0.0
Erythrina abyssinica	Koli	0.3	0.4	0.2	0.6	0.0	0.0	0.0	0.0
Eucalyptus species	Kalitunsi	2.9	4.0	2.3	1.9	2.0	2.0	2.0	2.0
Ficus gnaphalocarpa	Makuyu	1.0	1.0	0.4	0.3	0.5	1.0	0.3	0.0
Ficus natalensis	Bongi	1.0	1.0	0.7	0.4	0.5	2.0	0.3	0.0
Ficus sp.	Raboki	1.1	1.1	0.7	0.3	0.3	2.0	0.3	0.0
Ficus vasta	Foyo	1.3	1.3	0.8	0.7	0.0	1.0	0.7	0.0
Grevillea robusta	Grevillea	2.8	3.8	1.8	2.3	1.7	-	3.0	3.0
Leucaena sp.	Lucina	0.0	4.0	4.0	0.0	-	-	-	-
Maesopsis eminii	Musizi	2.0	2.0	1.3	1.0	1.0	2.0	1.0	-
Mangifera indica	Muyembe	2.0	2.1	1.3	1.3	1.5	2.0	0.7	0.5
Margaritaria discodeus	Ratego	0.6	0.6	0.4	0.2	1.0	1.0	0.3	0.0
Markamia lutea	Musolia	1.5	2.5	1.1	0.4	0.5	3.0	0.0	0.0
Melia azedarach	Lira	1.9	2.5	1.4	1.6	1.8	2.0	0.7	0.5
Moringa oleifera	Moringa	1.4	1.4	1.1	0.9	0.5	2.0	0.3	0.0
Persea americana	Avocado	2.1	2.3	1.0	1.3	1.5	0.0	0.0	0.5
Piliostigma thonningii	Ogeli	1.2	1.7	0.7	0.3	0.5	1.0	0.3	0.0
Psidium guajava	Mapera	1.5	2.1	0.9	0.8	1.3	2.0	0.3	0.0
Senna sp.	Gasia	1.0	2.0	1.0	1.4	1.0	2.0	1.0	0.0
Tamarindus indica	Chwa	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Tephrosia candida	Tephrosia	2.0	2.0	2.0	0.0	-	-	-	-
Terminalia velotina	Opok	1.6	1.6	1.0	0.8	0.5	2.0	0.3	0.0

Damage levels were scored as: 0= none, 1= minor, 2= moderate, 3= high, 4= very high. Only the most important tree species reported to be attacked by at least one termite species are included in the table. See text for tree species not attacked by any termite species.

Amagoro B, who planted *Tephrosia candida* and *T. vogelii* in the same garden, reported that Agoro, Ripo and Magere consistently damaged the former, but not the latter.

Crop damage
Farmers mentioned 23 main crops cultivated in their villages (Table 5). All termite species reported as damaging to trees were also known to damage most of the crops. In addition, farmers reported damage to some crops by Miyal (*P. spiniger*), which had not been reported as damaging to trees, but the damage by this species was generally rated as low (Table 5). Crop damage by Singiri (*O. latricius*) and Rudho (*A. truncatidens*) was reported only in Morkiswa and Osukuru Corner respectively. Farmers in all the villages studied said that banana, soybeans, yams and a *Solanum* species (Ntula) were not attacked by any termite species. They considered this was because banana is too watery and Ntula too bitter. Only farmers in Asinget A village reported attacks on sweet potato by some termites, especially *M. bellicosus* (Ripo), but farmers in the other villages considered the crop too milky to attract termites. Crops rated as highly susceptible included cassava, maize, rice, sugarcane, millet, sorghum and groundnuts.

Annual patterns of rainfall and termite damage levels

Farmers generally illustrated, with a few variations, two distinct wet seasons annually in Tororo District, the first rainy season occurring from March to June and the second between August and November .

Overall, farmers considered termite damage to be higher in the dry months (December to March, and June to July) than in the wet ones. They attributed high termite damage in June, July, November, December and January mainly to the fact that several crops, especially maize, millet, groundnuts and sorghum, matured and were harvested in these months. According to them, the crops are most susceptible to termite attack at maturity (from tasseling/seed set to harvest). Termite damage in February, March and August was generally rated to be low to moderate because, according to farmers, these are the months for field preparation and planting with relatively fewer crops, mostly perennials and trees, available for termites to attack. Farmers in Morgwang gave this same reason for rating termite damage as low in January and February in their village.

Termites as a food source

The commonly mentioned edible termite products were alates (locally called Ngwen) and mushrooms (called Obwol in Japadhola). It was reported that only soldiers of Agoro (*M. subhyalinus*) were garnered, mostly by boys, and eaten by males only. However, both men and women reportedly consumed soldiers and workers accidentally mixed with alates while collecting the latter. Of the 14 termite species, only 10 were said to be consumed by humans (Table 6). Aming (*B. aurivilii* and *C. ugandensis*), Kithea (*Microcerotermes* species),

Table 5 Farmers' rating of termite damage to crops

Crop	Mean damage score								
	Agoro	Ripo	Magere	Wambwe	Sisi	Miyal	Ogwee	Singiri	Rudho
Banana (Matoke)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
Beans (Maragwe)	1.6	1.8	0.5	1.1	0.8	0.0	0.5	0.0	0.0
Cabbage (Kabic)	0.6	1.1	0.8	0.0	0.3	0.0	0.0	1.0	0.0
Cassava (Mwogo)	4.0	4.0	2.3	2.6	2.0	1.0	1.5	1.0	4.0
Coffee (Mwanji)	1.6	2.3	1.0	1.1	1.5	0.0	0.5	2.0	4.0
Cowpea (Ngori)	1.5	1.6	0.5	1.0	1.3	0.5	0.5	2.0	0.0
Eggplant (Birinyanya)	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Groundnuts (Amaido)	3.1	3.6	0.3	0.9	0.9	0.0	0.5	1.0	0.0
Maize (Duma)	3.9	4.0	2.7	2.9	2.7	1.5	1.0	1.0	4.0
Millet (Kal)	3.8	3.5	0.9	1.0	2.0	0.5	0.5	1.0	0.0
Solanum sp. (Ntula)	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	*
Onion (Ntungulu)	2.7	2.7	0.7	1.0	1.0	0.0	0.0	1.0	*
Passion fruit (Matu)	1.8	1.9	1.0	1.1	1.5	0.0	0.5	2.0	0.0
Peas (Lapena)	2.0	2.1	0.6	0.6	0.8	0.0	0.5	0.0	0.0
Pineapple (Nanansi)	0.5	1.8	0.0	0.5	0.0	0.0	0.0	0.0	4.0
Rice (Mucere)	4.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	*
Sesame (Nyim)	0.5	1.0	0.4	0.4	0.5	0.0	0.0	0.0	0.0
Sorghum (Bel)	3.4	3.8	1.1	1.4	1.8	1.5	1.0	1.0	0.0
Sugarcane (Nyang)	3.8	3.9	3.1	2.1	1.7	0.0	1.0	2.0	4.0
Soybeans	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yams (Pama)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweet potato (Rabwo)	0.3	0.5	0.1	0.1	0.2	0.0	0.0	0.0	0.0
Tomato (Nyanya)	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Crop not mentioned in the village where the termite is known to be causing damage.
Damage levels were scored as: 0= none, 1= minor, 2= moderate, 3= high, 4= very high.
Japadhola names of crops in parentheses

Rudho (*A. truncatidens*) and Thuk (*T. oeconomus*) were not eaten. Kithea was reported as having no alate, and farmers cited three reasons for not eating Aming, Rudho and Thuk. These were: the alates are too small; they cause deafness – (Aming only); and no elder has been seen eating or has been said to eat these species. Preparation of termites for consumption involves mostly frying or boiling fresh harvests, which are dried for consumption as snacks or sauces of various types. Consumption of live termites with or without salt, and preparing a sauce of fresh (not dried) alates were also reported to be common.

Table 6 Farmers' rating of termites as a food source

Termite	Alates (mean score)		Mushroom (mean score)	
	Female	Male	Female	Male
Agoro	9.9	9.3	6.5	6.5
Sisi	9.0	9.5	5.7	5.5
Ripo	7.3	5.9	-	-
Wambwe	6.6	4.1	4.7	4.3
Magere	5.0	5.4	5.0	5.8
Miyal	4.8	4.8	1.5	2.3
Ogwee	4.5	6.0	3.5	4.3
Singiri	3.9	3.6	3.0	2.7
Majiji	2.6	4.9	-	-
Mbala	1.7	1.4	-	-

Alate ranks 1, 2, 3 …10 converted to scores as 10, 9, 8, …1 respectively.
Mushroom ranks 1, 2, 3 …7 converted to scores as 7, 6, 5, …1 respectively.
– indicates termite doesn't produce mushroom.

There were some variations between women and men in rating termites as a food source (Table 6). Women rated the alates of Agoro (*M. subhyalinus*) as the most delicious followed by Sisi (*P. militaris*), while for the men it was the other way round. Although the alates of Ripo (*M. bellicosus*) are generally larger than those of Sisi the former was reported to cause running stomach, and was consequently ranked third and fourth by women and men respectively (Table 6). Men ranked Ogwee (*Odontotermes* species 1) third for alates, but this species was ranked seventh by women, apparently because it was mostly gathered by males, especially boys, who either consumed a greater portion of their catch from the field or used them for trapping birds. The palatability of alates of Singiri (*O. ?latricius*), Majiji (unidentified species) and Mbala (*Odontotermes* species 2) was generally rated low by both sexes.

The farmers mentioned a total of seven termite species which produced edible mushrooms (Table 6). Those produced by Aming (*B. aurivilii* and *C. ugandensis*) were not eaten because they were believed to cause madness. Several other types were reported, including oruka, limesi and nyacok from Agoro (*M. subhyalinus*); okinyi and eumesi from Magere (*O. kibarensis*); okinyi, nyaguti, amoka and akwaro from Wambwe (*Pseudacanthotermes* species); nyaguti, okinyi, amoka and akwaro from Sisi (*P. militaris*); nyakilera from Singiri (*O. ?latricius*); and obusoukere and okinyi from Ogwee (*Odontotermes* species 1). No specific local names were given to mushrooms from Miyal (*P. spiniger*) or Aming (*B. aurivilii* and *C. ugandensis*); they were referred to as 'obwol Miyal' and 'obwol Aming' respectively in

Table 7 Termite control methods attempted by farmers in Tororo District

Method	How applied	Termite species	Effectiveness
Trenching (Mukula)	Dig trenches to direct running water into termite mound through vents (Ripo) or holes dug on the side of mound (Agoro).	Ripo and Agoro	Highly effective against Ripo during periods of heavy rainfall, but not effective on Agoro. Sometimes the termites migrate and make a new nest.
Queen removal	Dig out the queen using a hoe.	Ripo and Agoro	Effective, but some mounds are recolonised, especially Agoro
Chemicals: Ambush, Fen kill, Thiodan, Dimethoate, Robo and Diazole	Make a hole on the top of the mound, mix chemical with water and pour into the hole.	Ripo, Agoro and Miyal	Highly effective
Red pepper (Kamulali)	Pound 1 mug (= 0.5 litre) of pepper + 1 mug of water and leave to ferment for 2-3 weeks. Pour the mixture through a hole made on top of mound and seal the hole.	Ripo and Agoro	Highly effective
Dregs of local brew (Jarara or Kangara)	Dig hole on top of mound and pour 20 litres (1 jerrican) of hot dregs of local brew into mound and seal.	Ripo and Agoro	Highly effective
Dry cell	Pound 10 used dry cells (flashlight batteries), mix with 10 litres of water and pour into mound through a hole made on the top.	Ripo and Agoro	Highly effective
Fire	Dig hole on top of mound, insert wood and grass and set fire to it, then seal to confine the smoke and heat. OR fill hole with dry cow dung, set it on fire and leave to burn slowly.	Ripo and Agoro	Highly effective against Ripo but fairly ineffective against Agoro
Rodenticide (rat poison)	Make a hole on top of mound using a metal rod, drop in two tablets of chemical, then seal the hole to confine the smell in the mound. OR Put rodenticide in hot water and pour the mixture into mound through a hole made on the top, then seal the hole. The mound starts stinking of rotting termites after a few days.	Agoro Agoro	Highly effective Highly effective
Paraffin	Dig hole on top of mound, pour in 150 ml of paraffin and seal the hole.	Ripo, Agoro and Magere	Highly effective against Ripo and Agoro, but only moderately effective against Magere
Dracaena sp. (Penyi)	Cut *Drasina* species and insert stem in maturing maize field to repel termites.	All damaging termites	Highly effective
Wood ash	Dig hole on top of mound and pour 5 mugs (1 mug = 0.5 litre) of hot ash and seal. OR Pour ash around the base of seedlings and cover with soil (tried on *Grevillea robusta*).	Agoro and Ripo Ripo	Highly effective Ineffective
Trenching around mound	Dig trench about 2 ft deep around mound.	Agoro and Ripo	Highly effective
Wood ash + Red pepper + paraffin + *Aloe* species (Okak)	Mix 1 basin of ash + 1 *Aloe* leaf + 0.5 mug of red pepper and 0.25 litre of paraffin and pour into mound.	Agoro	Highly effective

Red pepper	Crush ripe red pepper fruits and mix with water in a ratio of 1 mug pepper : 10 litres water. Dig hole on top of mound and pour the mixture through the hole. No need to seal up the hole.	Ripo	Highly effective
Ash + red pepper	Make a trench round transplanted tree (tried on *Grevillea robusta*) seedlings. Trench should be about a foot deep and a foot away from seedling. Mix crushed red pepper with ash and place in the trench at intervals of about six months.	All damaging termites	Highly effective
Tithonia and red pepper	Mix leaves of *Tithonia* and red pepper in water and ferment for 2–3 days, pour into mound through a hole made on the top, and seal the hole.	Agoro	Moderately effective. Some colonies regenerate.
Mudfish intestine	Dig hole on top of mound, insert mudfish intestine and seal the hole.	Ripo	Highly effective
Snake	Insert dead snake into mound through a vent and seal the vent.	Ripo	Highly effective
Bidens pilosa (Sere)	Collect seeds of black jack and put around the base of maize plants.	Wambwe	Highly effective
Hot water and paraffin	Boil 5 litres water, mix with 300 ml paraffin, then pour through a hole made on top of mound and seal.	Ripo and Agoro	Highly effective
Cow dung	Dig hole on top of mound, put in 1 basin of cow dung and pour 20 litres of boiling water through the same hole.	Ripo and Agoro	Highly effective
Human urine	Collect a basinful of human urine and pour into mound through a hole made on the top, then seal. OR Ferment the urine for 2 weeks and spot apply around seedlings. One farmer tried this method on *Eucalyptus*, applying it more than once, but not at regular intervals and not using a standard dose.	Ripo, Agoro, Wambwe & Singiri All damaging termites	Highly effective against Agoro, but not effective against Ripo, Wambwe and Singiri Effective
Opium (Musala or Bangi) and/or tobacco	Time: season when alates emerge. Blow smoke of opium and/or tobacco into the mound through the alates' exit holes. A lot of alates come out and the remaining castes (queen, workers, soldiers) all die.	All alate producing termites	Highly effective
Used engine oil	Dig hole on top of mound and pour 0.5 litre of oil into mound. Do not seal hole.	Ripo	Not effective
Bedbug poison (name unknown)	Mix bedbug poison with one basin of water (about 10 litres) and pour into mound through a hole made on the top.	Ripo	Highly effective
Sealing vents	Seal all vents on mound using banana stems.	Ripo	Low effectiveness because the termites start damaging crops or trees when the banana stems in the vents are rotten.

Japadhola. On average, both women and men rated mushrooms from Agoro to be the most palatable followed by those, especially okinyi, from Sisi and Magere (Table 6). In contrast, both women and men rated mushrooms from Miyal as the least palatable. In addition to being eaten as food, okinyi was used as a medicine for running stomach in Amagoro B.

Control of termites

Only a few farmers knew about the various termite control methods. They mentioned several methods they had attempted, the majority of which were based on indigenous knowledge (Table 7). The majority of the farmers, who knew very little about controlling termites, viewed the PRA meetings conducted during this study as an excellent opportunity for them to learn from their colleagues. Generally, the farmers' attempts at termite control involved application of plant extracts, cow and human urine, heat and/or smoke, fish and snake remains, physical methods (removing the queen, trenching, sealing vents), and chemical methods (insecticides, rodenticides and used engine oil).

Most control methods were attempted on Ripo (*M. bellicosus*) and Agoro (*M. subhyalinus*) (Table 7), indicating the importance of these species as pests. The only methods rated by farmers as ineffective were application of wood ash around the base of *Grevillea robusta* seedlings and application of used engine oil to mounds of Ripo (Table 7). They also reported a number of problems that were limiting their efforts (Table 8). Inadequate knowledge and skills regarding termite control was rated as the farmers' most pressing problem in nearly all the villages studied, followed by lack of money to buy chemicals. The farmers considered chemicals dangerous, especially because some people had committed suicide using them. The risk of snake and termite bites was rarely cited as a major problem (Table 8).

Overall, farmers wanted eight termite species controlled in their villages (Table 9). The farmers consistently rated Ripo (*M. bellicosus*), considered the most damaging, to be controlled first, followed by Agoro (*M. subhyalinus*). Although Miyal (*P. spiniger*) was reported to damage some crops (Table 5), farmers considered this species not worth controlling because it generally causes only minor damage. Similarly, a need to control Ogwee (*Odontotermes* species 1) and Singiri (*O. ?latricius*) was mentioned in only a few villages: Morkiswa and Kagwara (Ogwee), and Aburi and Kagwara (Singiri). Farmers wanted Rudho (*A. truncatidens*) controlled mainly because it damages houses, granaries and stored agricultural produce.

Table 8 Farmers' main termite control problems

Problems	Number of villages	Mean score*
Inadequate termite control knowledge and skills	8	8.5
Lack of money to buy chemicals	8	8.1
Chemicals expensive	8	6.0
Chemicals dangerous to humans	7	5.6
Some termites difficult to control	8	5.1
Risk of snake bites	1	5
Damaging termites edible	7	4.9
Lack of chemicals	6	4.2
Painful bites by some termites	2	1.5

* ranks of ,1, 2, 3, ……9 converted to scores 9, 8, 7 …..1 respectively

Table 9 Farmers' priorities for control of different termite species

Termite	Number of villages	Mean score*
Ripo	8	8.0
Agoro	8	7.0
Magere	7	5.2
Wambwe	8	5.1
Sisi	4	4.5
Singiri	2	4.5
Rudho	8	3.7
Ogwee	2	3.5

* Ranks of 1, 2, 3, ……8 converted to scores as 8, 7, 6 …..1 respectively.

4 DISCUSSION

Pest status, diversity and distribution of termites

Farmers rated termites as their most important constraint to tree growing, suggesting that they would be receptive to innovative termite control measures. However, they cited a number of other problems, some of them ranked highly (Table 1), which should not be overlooked. The efficacy of locally designed bait traps against moles should be evaluated. Lack of planting material requires education of farmers in seed production and harvesting, as well as in good nursery practices in order to raise healthy seedlings. Research is necessary to identify and ascertain the losses caused by defoliating caterpillars, and fruit pests and diseases mentioned by the farmers. The effects of prolonged dry spells may be minimised by early planting of seedlings or seeds. This requires proper timing of seed sowing in nurseries, in those cases where nursery seedling are required, to match the onset of the long rainy season. Farmers in all the villages studied considered damage from livestock to be another problem limiting tree cultivation. Reports on livestock management in other parts of Uganda (Nyeko et al., 2002; 2004) indicate that farmers tether their livestock, graze them in paddocks, or use local courts for negligent livestock owners.

A basic knowledge of pest biology and ecology is a prerequisite for adequate pest management. Such information is crucial to the design and success of control measures and even to the initial evaluation of the need for control (Logan et al., 1990). In this study, the farmers demonstrated that the use of simple features such as mound building character, mound morphology, timing of alate flights, and size, colour and/or odour of workers, soldiers and alates are effective indigenous means of identifying termites. Indeed, farmers called all termites encountered in this study by their Japadhola names, which were remarkably consistent with scientific identifications (Table 3). However, such indigenous taxonomic skills seemed limited to a few farmers. Mechanisms are necessary to promote farmer-to-farmer dissemination of such important information. In addition, local names of pests need to be compiled so that researchers and extension workers can communicate effectively with farmers on particular species rather than using general names of pest groups such as termites, which comprise of over 2600 described species (Kambhampati and Eggleton, 2000). Logan et al. (1990) has pointed out that non-specialists often approach termite control as if a single pest were to be dealt with. This is unfortunate since termite species differ in their ecology and biology, and the majority are not pestiferous (Bignell and Eggleton, 2000).

The farmers reported a marked variation in topographic distribution of a number of termite species (Table 3). This is indicative that some localities were more attractive for nest establishment than others. In analysing the distribution of *Amitermes laurensis* mounds in Australia, Holt and Greenslade (1979) identified vegetation pattern and soil properties as important factors in the distribution of the species. These authors observed that *Amitermes* was absent from very low-lying, poorly drained sites and that differences in mound-building fauna from one site to another were related to differences in drainage capacity. Similarly, Nel and Malan (1974) noted that mounds of *Trinervitermes trinervoides* were not randomly distributed over the veld in South Africa but tended to aggregate in certain areas. Such information is important in selecting sites for planting tree species and crops susceptible to the particular termite species. For example, *Macrotermes bellicosus* reported in this study to be very rare in valleys may not be a serious problem to trees and crops planted in such locations even though the species is generally known to be a serious pest.

Macrotermes bellicosus and *M. subhyalinus* were generally rated as the most damaging (Tables 4 and 5). The genus *Macrotermes* includes several important pests of a wide range of field crops and trees (Cowie et al., 1989). They attack plants by cutting off young seedlings or mature plants at soil level (Pearce et al., 1995). *Odontotermes kibarensis* (Magere) was also reported in this study to cause considerable damage, especially to tree seedlings and crops. Generally, many *Odontotermes* species have been recorded as pests of field crops, fruit trees, and both seedling and mature plantation trees (Pearce et al., 1995; Sands, 1998). Utilisation of tree bark under the cover of clay runways and sheetings is characteristic of foraging in this genus (Sands, 1998). Cereals such as maize and sorghum are lodged by *Odontotermes*, the termites eating through the stem or weakening the roots (Pearce et al., 1995).

Pseudacanthotermes attacks have been recorded on various field crops and nursery or newly transplanted tree seedlings (Cowie et al., 1989; Pearce et al., 1995; Sands, 1998; Sekamatte, 2001). In this study, farmers rated a number of *Pseudacanthotermes* species as minor pests of trees and crops (Tables 4 and 5). Farmers considered *Amitermes ?truncatidens* (Rudho) a serious post-harvest pest. *Amitermes* are known to occur mainly on dead wood, ungulate dung or grass, but some species for example *A. evuncifer* has been reported as a pest of root crops such as yams, groundnuts, sugarcane and some trees (Pearce, 1995; Sands, 1998). A characteristic of this genus is the excavation of cavities within the plant or pods, which are lined with black sheeting (Pearce, 1995). The farmers' perception that *Trinervitermes oeconomus* and a *Microcerotermes* species (Kithea) were not damaging to crops and trees needs to be verified. *Trinervitermes* species have been recorded as nocturnal pests, damaging young cotton, but depredations on grass crops including sugarcane, upland rice and wheat are more important, and *T. trinervoides* is regarded as a significant pest of pastures in southern Africa (Sands, 1998). Similarly, although the genus *Microcerotermes* consists mainly of wood-feeders, some species such as *M. parvus* have been recorded as pests of trees and crops (Harris, 1969; Pearce, 1995). *Cubitermes* has not been reported as damaging any crop or tree except for occasional reports of forages in contact with yam tubers, where their presence is likely to be secondary (Sands, 1998). Similarly, *Basidentermes* appears to be a soil-feeding genus without economic significance (Sands, 1998).

Marked variations were reported in the level of termite attack on trees and crops, with some tree species (Table 4) and crops (Table 5) being considered resistant to all termite species. Differences in resistance between plant species, varieties and provenances to termites are widely reported (e.g. Amin et al., 1985; Mitchell et al., 1987). However the degree of resistance may also be influenced by other factors such as locality, and plant age and condition (Cowie et al. 1989; Logan et al., 1990). The use of resistant trees and crops is the only certain method of reducing termite attack in agroforestry. Surprisingly, however, very little is known about termite resistance of the various species promoted for agroforestry. With the restrictions on the use of persistent insecticides, there is generally increasing interest in the use of resistant plant species, although accurate knowledge of their differing susceptibility is scarce (Logan et al., 1990). Preliminary trials to ascertain the best compromise between resistance and growth rates for a particular area are thus necessary before scaling up the cultivation of especially newly introduced species. In addition, studies on the genetic and chemical components responsible for termite resistance might achieve greater gains from breeding programmes.

Farmers reported the level of termite damage to trees and crops as most severe in dry periods and at crop maturity. A similar negative relationship between termite damage and rainfall was reported by farmers in the Darfur region of the Sudan (Pearce et al., 1995), and this is consistent with the general notion that peak termite attack on crops and trees occurs during dry periods (Logan et al., 1990). Lepage (1982) observed that periods of intense foraging of *Macrotermes* species reflect the internal economy of the colony. In tropical environments where swarming occurs early in the rainy season, the highest food demand for nymphal maturation occurs during the dry season, and this suggests a constant adjustment of foraging to the needs of the colony (Lepage and Darlington, 2000). It is therefore important to plant at the correct time to avoid drought periods. Sands (1977) observed that crops are often more seriously damaged towards harvest than earlier in the season, but this depends on the species of termite involved (Wood and Cowie, 1988). In this study farmers pointed out that maize, millet, sorghum and groundnut were damaged most by termites during maturity. Prompt harvest of such crops may therefore reduce yield loss. Delays in harvesting can also lead to yield loss through lodging (e.g. in maize and millet) or pod/peg damage in groundnuts.

Termite control practices

Any attempt to manage termites needs careful consideration of their benefits against the loss to the ecosystem and local communities. The most obvious beneficial roles of termites in the ecosystem are decomposition and tunnelling, which loosen and aerate the soil (Bignell and Eggleton, 2000), and can thus help reclaim compacted and encrusted soils. The alates are widely harvested for domestic consumption and/or sale in several African countries (Wardell, 1987; Fasoranti and Ajiboye, 1993), thereby providing a supplementary source of protein and income. However, it was clear in this study that not all termite species are consumed by humans, and that there is marked variation in the palatability of the species consumed (Table 6). It is therefore important to identify the species preferred for food and those considered as pests when designing management strategies. Species such as *Macrotermes subhyalinus* (Agoro), which was rated as very damaging to crop, but rated by farmers as producing the most delicious alates and mushrooms, may cause conflicts of interest. Surprisingly, farmers did not rate this problem highly among their major constraints in controlling termites (Table 8). However, such conflict of interest is likely to be more pronounced in situations where mounds of edible pestiferous termites are owned for alates and/or mushrooms, and the termites from the mounds are damaging to crops and/or trees belonging to neighbours. These conflicts underline the importance of identifying cultural methods with minimal application of insecticides.

The farmers mentioned several indigenous control methods that they had attempted against termites (Table 7), but knowledge of such methods seemed limited to only a few of them. Removal of the queen and/or destruction of the nest have frequently been used by farmers as traditional methods for control of mound-building termites, apparently because their nests are readily identified and the royal chamber easy to locate (Logan et al., 1990). Mounds are physically destroyed, flooded or burnt with straw to suffocate and kill the colony. However, young colonies may remain entirely subterranean for their first few years and may thus be difficult to identify. In addition, if nymphs or alates are present at the time of de-queening, replacement reproductives may develop (Darlington, 1985). This apparently explains the farmers' observation that de-queened mounds are sometimes recolonised. Even so, this method may reduce overall numbers of termites, and reduction in foraging activities may be for a sufficient period to allow young trees to become established or offer short-term protection to crops (Cowie et al., 1989). However this is only in cases where mound-building species are the only serious termite pests (Logan et al., 1990). Another drawback of physical destruction of mounds is the very intensive labour requirement, and this may render it impractical in areas where the density of termite mounds is very high.

The use of wood ash and locally available plants containing substances toxic or repellent to termites has often been suggested on the basis of long-established local practice (Wardell, 1987). Wood ash heaped around the base of the trunk has been recorded as preventing termite infestation of coffee bushes. Wood ash is also reported to repel termites from date palms, to protect stored yams and maize, and to be effective in protecting tree seedlings if mixed into plant nursery beds or applied in a layer below polythene planting tubes (Logan et al., 1990). In contrast, application of wood ash at the base of *Grevillea robusta* seedlings was reported to be ineffective against *Macrotermes bellicosus* (Table 7). This disparity may be attributed to variability in termite species, method of application or wood species used for producing ash. Therefore studies aimed at verifying the potential benefits of using wood ash for termite management in agroforestry are necessary. Cowie et al. (1989) pointed out that the use of wood ash in termite control has not been evaluated rigorously, and that its efficacy remains speculative. Similarly, various parts of plants and plant extracts are known to be either toxic or repellent to pests of agriculture, and are widely used in rural settings without specific recommendations for their large-scale utilisation (Logan et al., 1990, Maniania et al., 2002). Some extracts such as those of neem, wild tobacco, *Tephrosia vogelli* and dried chilli have been used to control termites in the field and in storage (Nkunika, 2002).

Information on the control of termites using dead animals such as snakes and fish reported in this study is very scant in the literature. Malaka (1972) reported that Nigerian farmers bury dead animals or fish viscera to reduce termite attack. In India, water containing decomposed fish, tobacco, salt, or washings from a bearskin were reported to keep termites from mango trees (Anon., 1898, cited in Logan et al., 1990). Although farmers claimed that the use of dead snakes and fish intestine is highly effective against *Macrotermes bellicosus* (Ripo), the rationale behind this is unclear. Possibly substances toxic to termites are released during decomposition of such materials. Nonetheless large-scale application of dead snakes in termite control seems particularly impracticable not only because the materials would be scarce, but also some snakes are poisonous to humans thereby posing a serious health risk.

No farmer had attempted mixed cropping to reduce termite infestation although the use of pegs of a *Dracaena* species in maturing maize was reported as highly effective against all termites damaging to maize (Table 7). Farmers in western Uganda reported reduced termite damage on *calliandra calothyrsus* when the species is intercropped with *Melia azedarach* (Nyeko et al., 2004). Sekamatte et al. (2003) observed that intercropping maize with soyabean caused significant reduction in termite attack, reduced loss of grain yield of maize and increased the nesting of predatory ants in maize fields. Such studies are necessary in agroforestry to examine the effects of tree/crop composition and planting pattern on termite infestation. In addition, research is necessary on the role of natural enemies such as ants and entomopathogens in controlling termites, a method that was not mentioned by farmers in this study. The effectiveness of granular application of *Metarhizium anisopliae* to control termites in a maize cropping system has, for example, recently been demonstrated in Kenya and Uganda (Maniania et al., 2002; Sekamatte, pers. com.).

Although the farmers reported a number of indigenous termite control methods in this study (Table 7), they rated inadequate termite control knowledge and skills as their most limiting constraint in termite management (Table 8), indicating that the farmers do not share pest control information. On the other hand, they are perhaps diffident about the use of traditional methods because they perceive them as backwards and primitive (Bottenburg, 1995). Indigenous pest control practices need to be documented, tested, adapted and promoted to farmers with other IPM measures so that farmers become less dependent on chemical inputs. In addition, education about pesticides to which farmers are already exposed would promote more selective, less dependent use and safe handling of such products, and provide farmers with a more objective basis for decisions about pesticide use in local systems. With new and traditional knowledge farmers themselves would then be able to develop suitable pest management technologies and make better decisions as to which technologies to accept and demand.

5 CONCLUSIONS

It was evident in this study that a wide range of pest and other constraints can limit on-farm tree cultivation. This calls for systematic consideration of farmers' problems in ongoing agroforestry activities. In this way, researchers, extension agents and farmers may identify problems that can be immediately alleviated through education, and those that require research before providing solutions to farmers. Overall, farmers rated termites as their most important constraint in tree cultivation. This suggests that solving termite problems is high on their agenda and that they will be receptive to innovative termite control measures in agroforestry.

This study has provided some basic information about farmers' knowledge of the biology, ecology and management of termites that could aid the development and promotion of sustainable termite control measures in agroforestry. Farmers demonstrated a deep knowledge of the diversity, abundance and topographic distribution of termites. With the aid of their indigenous identifying characteristics, local termite taxonomists identified a total of 14 termite species in their local names, which were remarkably consistent with scientific identifications. Such indigenous pest taxonomic knowledge needs to be documented and promoted to facilitate communication between farmers, extension agents and scientists on specific pest problems.

The use of resistant tree and crop species is the only sure method of minimising termite damage in agroforestry. However, very little is known about the resistance of the various tree species and crops being promoted for agroforestry. In this study, several tree species and crops were reported to be resistant to termite attacks. The resistance of such species should be verified for expanded on-farm cultivation in areas with termite infestations. This can be done through the establishment of trials aimed at ascertaining the best compromise between resistance and growth rate for particular areas. Information is also necessary on tree/crop species combinations and arrangements (spatial and temporal) that would minimise termite damage in agroforesty.

The farmers had attempted a number of control methods, especially against *Macrotermes bellicosus* and *M. subhyalinus*, the majority of which they claimed were effective. However, they rated their lack of termite control knowledge and skills as their most important problem in termite management. This is apparently because much of the indigenous control knowledge is limited to a few individuals. Clearly, mechanisms are needed to educate farmers on appropriate termite management strategies and to encourage farmer-to-farmer transfer of such information. The various indigenous control practices reported by farmers in this study need to be verified, standardised and promoted with other IPM measures with the aim of reducing application of chemical pesticides in agroforestry. The farmers' field school approach and community advisory concept (Norton et al., 1999; Price, 2001) could be excellent ways for agencies promoting agroforestry to both generate and spread (IPM) information among farmers.

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