Ethiop. J. Biol. Sci., 6(2): 115-128, 2007
 ISSN: 1819-8678

PREVALENCE OF TERMITES AND LEVEL OF DAMAGE ON MAJOR FIELD CROPS AND RANGELANDS IN MANASIBU DISTRICT, WESTERN ETHIOPIA

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ABSTRACT: The current status of termite damage on maize (*Zea mays* (L.)), teff (*Eragrostis tef* (Zuccagni) Trotter), sorghum (*Sorghum bicolor* (L.)) and rangelands was studied in five Kebele administrations (study sites) and on three farmers' fields in every Kebele, in Manasibu District, Wellega Zone of Oromiya Regional State. Termite samples were collected from infested crop fields and rangelands, identified to the genus level with keys to the Ethiopian termites, and percentage occurrence for each genus was determined. Six genera of termites: *Ancistrotermes, Macrotermes, Microtermes, Odontotermes, Pseudacanthotermes* and *Trinervitermes* were identified. The first five genera belong to the subfamily Macrotermitinae whereas *Trinervitermes* belongs to Nasutitermitinae. All of the genera belonged to the family Termitidae. Subterranean termites in general and *Microtermes* in particular, were found to be the most prevalent termites in the study area. The damage that termites caused to maize and sorghum were assessed by the use of quadrates and that of teff by laying wooden frames in the quadrates. For all the three crops, damage was assessed at vegetative, flowering, and maturity stages. It was found out that the levels at which the three crops were damaged by termites were significantly different from each other. Teff was the most seriously damaged crop in the study area, followed by maize, while sorghum was the least affected crop. Damage at different stages, within each crop, were also found to be significantly variable from each other. To evaluate the impact of termites on rangelands in the absence and presence of grazing by livestock, three plots of rangelands were fenced and protected for six months. It was found that the protected plot of the rangelands significantly had higher percent vegetation cover and lower number of termite foraging holes per m^2. From the study, it can be concluded that the genus *Microtermes* was the major termite species attacking crops and rangelands in Manasibu district, implying that most control strategies should focus on this genus, especially to control termites on teff and maize.

Key words/phrases: Damage, Field crops, Prevalence, Rangeland, Termite

INTRODUCTION

Owing to their feeding behavior, termites are injurious to field crops and plantations, forestry, and rangelands, among others. Studies on food preference of termites indicate that the main nutritional ingredient in their

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food is cellulose; nearly all sources of structural components are consumed by termites (Wood and Lee, 1972; Baklenov and Guseve, 1973; Cheok and Wong, 2001; Pesticide Educational Resources, 2002). Some termites harvest fungi, and some others feed on humus and organic matter from the soil (Richards and Davies, 1978).

Termites destroy various crops of paramount economic importance. They also damage pasturelands, which are primarily used for livestock production. Ethiopia is among the tropical countries where crops and pasturelands are severely damaged by termites. A number of reports indicate that the problem has become more severe in western Ethiopia (Abdurahman Abdulahi, 1990; B & M Development Consultants, 1997; Gauchan *et al*., 1998). There is, as a result, growing interest in evaluating the level of damage that termites can cause to the major crops that are growing in western Ethiopia such as *Zea mays, Eragrostis tef* and *Sorghum vulgare* and also in assessing the possible interactions between grazing and termite impacts on rangelands as keeping livestock is one of the major agricultural activities of that part of the country. There is also a need to determine which type of termite group is more prevalent in field crops and also in the rangelands.

The Ethiopian zoogeographical region, in general, is the richest in termite fauna and is known to be center of origin for many species (Bouillon, 1970). In Ethiopia, there are 61 species of termites placed in 25 genera and four families, of which very few are regarded as pests (Abdurahman Abdulahi, 1990). According to Oromiya Agricultural Development Bureau (1996) and B & M Development Consultants (1997), the damage caused by termites in western Ethiopia became more and more acute in the last 40-50 years. West Wollega zone has been known to suffer from increasing termite problems for the last 20 years, and it is now spreading rapidly in easterly direction from the affected districts of the west (Gauchan *et al*., 1998). These reports underlined that the problem has become so complex that the farmers around Mendi, the major town of Manasibu District in western Ethiopia, have been forced to abandon their lands and move to less affected lowland areas. It is possible to note from this that termite problem in Manasibu District has serious socioecological implications. Cowie and Wood (1989), from a quick and non systematic observation, reported that termites cause heavy damage to maize and teff in western Ethiopia. They reported that up to 6% of grass was also covered by termite soil sheeting and an average of 15 foraging holes per m^2.

Most data available on the level of damage caused by termites on the major crops of Manasibu District were obtained in most cases from farmers' complaints (B & M Development Consultants, 1997) or taken at most from field observations done at only one stage of development of the crops, and there was totally no data on teff (Cowie and Wood, 1989). Wood (1986) recommended that fencing a small area of denuded rangeland would help to compare the impact of termites on rangeland in the presence and absence of grazing by livestock. The present study was, therefore, intended to evaluate the level of damage that termites can cause to *Z. mays*, *E. tef*, and *S. vulgare*, through consistent follow up of the three stages of development of the crops, on the same plots for every crop in the study area. It was also aimed to assess the relations between overgrazing and termite impacts on rangelands.

MATERIALS AND METHODS

Description of the study site

The study was conducted in Manasibu district, which is located in west Wollega Zone of Oromiya Regional State, western Ethiopia (Fig.1). The district is climatically classified into lowland (68.3%), and middle highland (31.7%), within elevation ranges of 1400 to 1860 meters above sea level (m.a.s.l.) (Physical Planning Department of Oromiya, 2000). The sites of the study (Kebele Administrations) were Lelisa Soyema (N 9^0 43' and E 35^0 19'), Ula Ganti (N 9^0 45' and E 35^0 17'), Dandi Gudi (N 9^0 42' and 35^0 12'), Lelisa Komis (N 9^0 4' and E 35^0 18') and Serbi (N 9^0 43' and E 35^0 15'). The coordinates of the study sites were recorded using Geographic Position System (GPS). From two kebele administrations, three localities were selected for termite impact investigation on rangelands. These were Odo Kello (N 9^0 41' and E 35^0 16') located at 1614 m. a. s. l, Odo Kabba (N 9^0 41' and E 35^0 15') located at 1568 m. a. s. l, and Serbi (N 9^0 43' and E 35^0 15') located at 1640 m. a. s. l. The main factor considered for selection of these localities was the availability of rangelands with appropriate sizes (not less than three hectares) that would remain uncultivated throughout the study period.

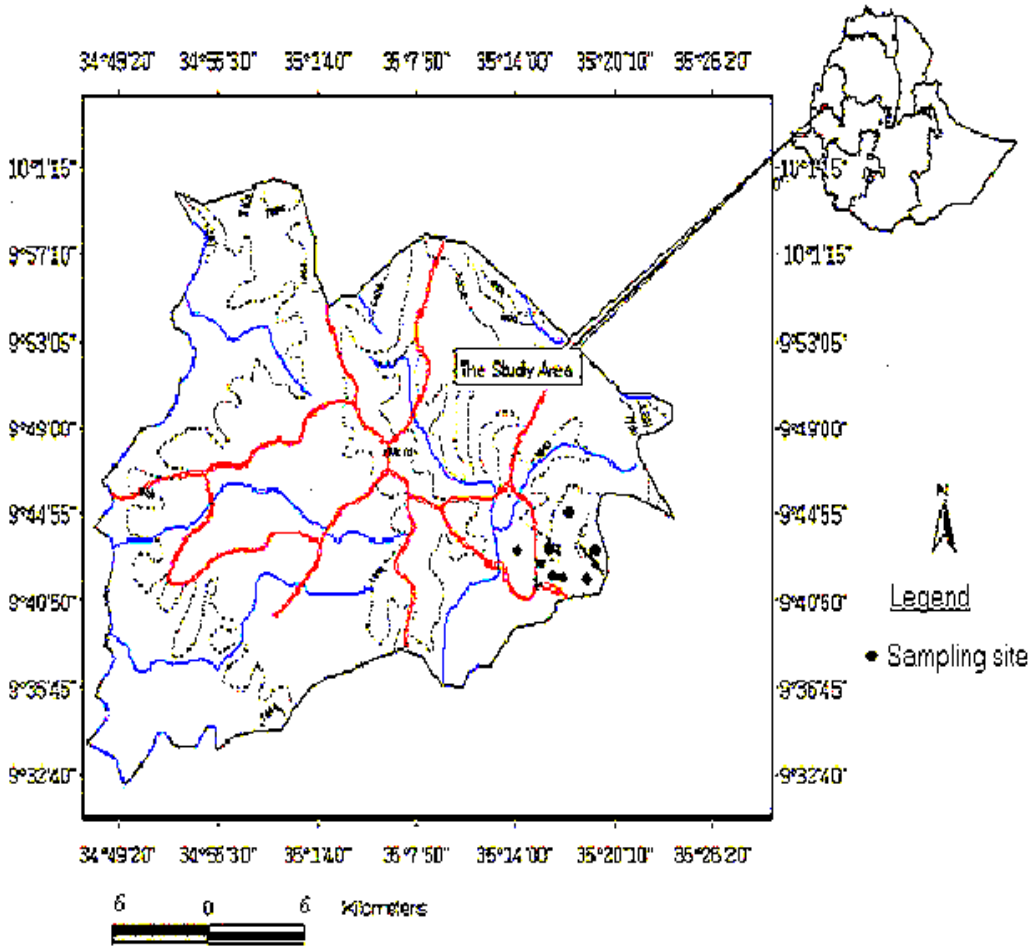

Fig.1. Location of study sites in Manasibu District, western Ethiopia

Collection, identification and determination of prevalence of termites

Z. mays and *S. vulgare* infested with termites were uprooted and their roots were split, and stems were dissected to collect the termites on plastic sheets. Termites observed foraging on *E. tef* and grasses in rangelands, within soil sheeting and surface runways, were picked up together with soil with the use of spade and placed onto plastic sheets, from which their soldiers were transferred into vials containing 80% ethanol. All the vials were sealed, labeled and taken to Insect Science Research Laboratory of Addis Ababa University for identification. The samples were investigated under binocular

microscope and identified to genus level through the use of Key to the Genera of Ethiopian Termites (Abdurahman Abdulahi, 1991), external morphology being considered as the main feature for identification (Krishna, 1970; Pearce, 1997).

Prevalence of every genus in each study crop and rangelands was determined as percentage occurrence, by dividing the total number of individuals of a genus by the total number of all termites in all sampled genera.

Termite damage level investigation on crops

Within the five study sites (Kebele Administration), investigation of damage caused to maize, teff and sorghum was done in farmers' fields. For each study crop, three study fields were selected in each Kebele, and investigation was done in 45 fields for all the three crops. Each study field had an area of 30 m X 40 m. Damage assessment was done at vegetative, tasseling /flowering/ heading, and maturity stages. All forms of termite attack were assessed. Damage was investigated at the center and the four corners of fields of the study crops, using quadrates, each with an area of 10 m X 10 m. For sorghum and maize, damage was estimated following the method of Abdurahman Abdulahi (1990), with some modifications. In this study, total count of damaged crops from each quadrate was divided by the total crop population in that quadrate and multiplied by 100 to obtain percent damaged plants. The mean damage from the five quadrates represented termite damage of that field. To avoid repeated counting, the damaged standing crops, which had already been counted were marked at the most tip parts by the use of enamel paints. For teff, percent of stems cut was quantified by lying a wooden frame of 1 m^2 containing 100 cells on the crop field within the defined quadrates. To attain this, wooden frame to which plastic strings were fixed in such a way that it contained hundred cells each with an area of 10 cm X 10 cm. Each cell represented 1% of 1 m^2. Mean damage from the five quadrates represented mean percent damaged plants in each teff field.

Investigation of termite impacts on rangelands

General surveys were made on and around the rangelands at the beginning of the study period. Fences were constructed on 50 m X 50 m plots of selected rangelands to exclude grazing by livestock. The fenced areas were guarded from the last week of August 2003 up to the first week of March 2004, while the areas outside of the fences were left free for livestock

grazing. At the end of the sixth month, percentage of vegetation cover (grass cover) and number of termite foraging holes per m^2 were recorded in protected and in unprotected plots of rangelands which were located in close proximity of one hundred meters from the protected ones. For the purpose of determination of foraging holes and vegetation cover, five quadrates each with an area of 10 m X 10 m were formed in such a way that one quadrate was located at the center and the other four were located at the four corners in all the plots. A wooden frame of 1 m^2, which contained hundred cells each with an area of 100 cm^2, was used to quantify percentage of vegetation cover. Mean of the values from the five respective quadrates were considered as mean percentage of vegetation cover, and mean number of termite foraging holes per m^2. Within these quadrates, effect of treatment (fencing and non-fencing) on height of grasses was also observed.

Data analysis

Independent t-test was used to compare termite damage to crops, numbers of termite foraging holes and percentage of vegetation cover. The data were analyzed using SPSS version 10.0 (Gomez and Gomez, 1984; SPSS Inc., 2000).

RESULTS

Topography of the study area

Most parts of the study area were characterized by undulating topography, with riverside forests in the valleys, and highly eroded and denuded hillsides. Coffee plantations occupied most of the forests, but maize was also grown in the valleys, following riverbanks in some localities. No termite infestations were encountered in such wetlands. In hillside rangelands, livestock were frequently observed grazing throughout the study period. The soil looks compacted and dry. Epigeal termite nests were rarely encountered. A total of three mounds were observed in all the three rangelands surveyed. The mounds were dome-shaped, having an average height of 50 cm. In those rangelands, they were all confined to under shades of bushes.

Status of termites on the crops

A total of 135 samples i.e., 45 samples of termites from each study crop, were collected from the study area. The termite samples were identified to five genera, namely Ancistrotermes, Macrotermes, Microtermes, Odontotermes, and Pseudacanthotermes (Table 1). All of them belong to the subfamily Macrotermitinae and family Termitidae. Relative percentage

occurrence of these genera indicated that Microtermes and Pseudacanthotermes were the most abundant among the samples collected from the target crops. Macrotermes was recorded on all the three crops, but less frequently, and Ancistrotermes was the least encountered termite genera in the study area (Fig.2).

Table 1.Termite genera on maize, teff and sorghum

Crop	Termite genera	% Occurrence
Maize	*Macrotermes*	20.0±2.2b
	Microtermes	40.0±3.6a
	Odonotermes	13.3±1.2c
	Pseudacanthotermes	20.0±2.2b
	Ancistrotermes	6.7±0.4d
Teff	*Macrotermes*	21.4±2.4c
	Odontotermes	35.7±3.2b
	Pseudacanthotermes	42.9±3.9a
Sorghum	*Macrotermes*	13.3±1.2b
	Ancistrotermes	6.7±0.4c
	Microtermes	66.7±4.6a
	Psudacanthotermes	13.3±1.2b

Means followed by the same letter (s) along each crop are not significantly different from each other at 5%, Tukey's studentized range test (HSD).

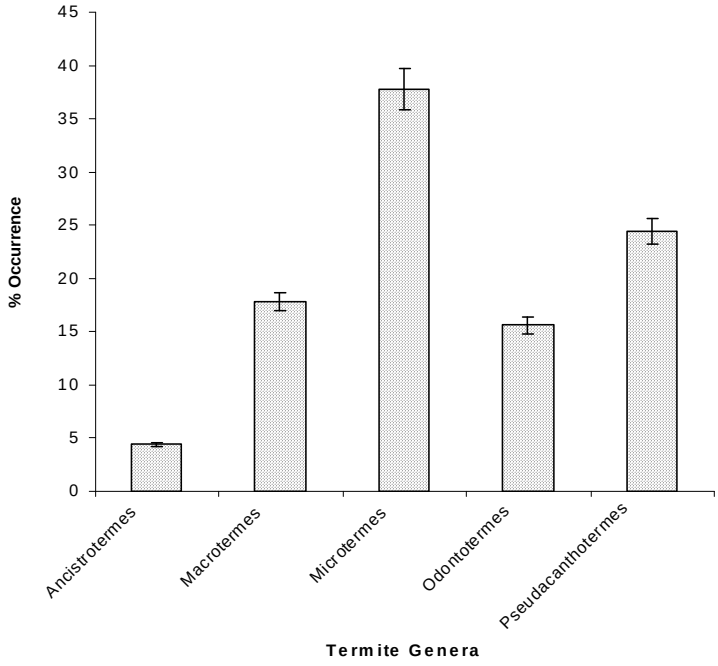

Fig.2. Percentage occurrence of termite genera in all fields of the study crops

It was found that these termite genera occurred at different percentages on different study crops. For instance, *Pseudacanthotermes* was found attacking teff much more than it attacked the other two crops (Table 1). *Microtermes* was encountered frequently in roots and stems of maize and stalks of sorghum, and it was also observed at the base of the roots of matured teff in Serbi site.

Damage on maize, teff and sorghum generally showed three forms: a) stems and stalks were cut near the surface b) roots were penetrated, stems excavated, and in some instances, filled with moist soil c) external parts were covered by soil sheeting. Stem cutting began at late vegetative stage and stopped before tasseling (heading) in maize and sorghum. However, in teff, stems were cut at all stages of growth, though less seriously at vegetative stage compared to flowering and maturity. It was known from termite samples collected and identified from infested crops that stems were cut by *Macrotermes, Pesudacanthoterms,* and *Odontotermes*. Root penetration was found to commence at late vegetative stage in sorghum and maize and continued throughout tasseling and maturity stages in maize. In sorghum, stem penetration was not observed after heading. Hollowing of standing stems of maize up to 50 cm high and filling with soil particles were observed in some fields. *Microtermes,* most frequently, and *Ancistrotermes* to a lesser extent, were encountered in roots and stems.

Covering external parts with soil sheeting was not common in standing maize and sorghum and was limited to the lower parts of their stems when it occurred. But maize which was lodged following root penetration was observed totally covered by soil particles and foraged by termites under the cover. It was in teff that the whole parts of the plant were covered by soil particles, particularly around maturity.

Maize, teff and sorghum were not equally damaged by termites (Table 2) and the difference in the level of damage was found to be significant ($P < 0.05$) among the crops. Teff and maize were highly infested, while infestation on sorghum was slight.

Comparison of levels of damage among different stages within each crop also showed significant differences ($P < 0.05$) (Table 3), but no damage was observed at maturity in sorghum.

Table 2. Mean percent of damaged maize, teff and sorghum by termites

Crop	Mean % damage ± SE
Maize	16.62±. 67b
Teff	29.89± 1.16c
Sorghum	1.52 ± .05a

Means followed by the same letter (s) are not significantly different from each other at 5%, Tukey's studentized range test (HSD).

Table 3. Mean percent of damaged maize, teff, and sorghum at different growth stages

Crop	Mean % damage ±SE		
	Vegetative	Flowering	Maturity
Maize	13.80±1.25b	8.59±.90c	8.69± .72a
Teff	14.28 ± 2.26a	31.83± 1.35b	43.54± 1.08c
Sorghum	2.31± .37c	1.42 ± .26b	0.71± 0.00a

Means followed by the same letter (s) within a row are not significantly different from each other at 5%, Tukey's studentized range test (HSD).

Status of termites in the rangelands

From rangelands of the study area Macroterms, Pseudacanthoterms, Odontoterms and Trinervitermes were collected, and they were found to occur in varying proportions (Fig. 3).

In all of the plots of rangelands which were protected from livestock grazing, grasses showed high level of regeneration, as opposed to unprotected neighboring areas. The height of most of the grasses in the fenced areas reached above 30 cm whereas that of the unprotected areas remained under 5 cm. The percentage of vegetation cover per m^2 was by far higher in the protected plots than the unprotected plots (Table 4), and the differences were significant ($P < 0.05$).

For the whole study area of the rangelands, the mean number of termites foraging hole per m^2 was found to be significantly greater ($P < 0.05$) in the unprotected plots than in the protected plots (Table 5). Density of termite foraging holes in protected and unprotected plots within each locality was also found to be significantly different ($P < 0.05$), except in one locality.

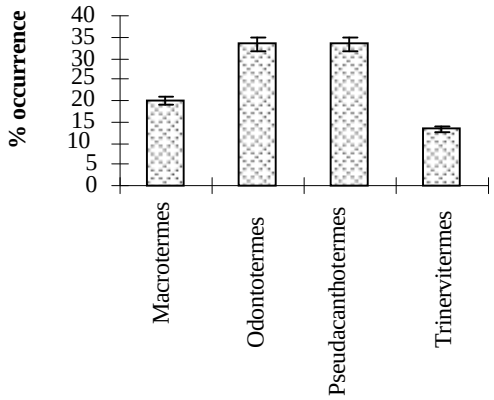

Fig. 3. Termite genera and their percentage occurrences in rangelands of the study area

Table 4. Mean percentage vegetation cover per m^2 in protected and unprotected neighbouring plots of rangelands in different localities

Locality	Mean % vegetation cover± SE	
	Protected	Unprotected
Oddo Kello	70 ± 6.52a	23.00 ± 1.82b
Oddo Kabba	66.00 ± 5.79a	29.20 ± 2.54b
Serbi	67.00 ± 10.32a	15.60 ± 2.77b
Overall mean	67.67 ± 4.19a	22.60 ± 1.97b

Means followed by the same letter(s) within a row are not significantly different from each other at 5%, Tukey's studentized range test (HSD).

DISCUSSION

The result of the present study indicates that subterranean termites in general and *Microtermes* in particular were the most widespread termite pests in field crops in Manasibu. This finding is in contrary to that of Cowie and Wood (1989) who reported that very few fields of maize suffered lodging due to *Micotermes* in Wollega, whereas attack by *Macrotermes* was widespread, and sorghum was solely damaged by *Macrotermes* in

Manasibu. Out of 45 samples of termites collected from damaged maize in 15 fields, 40% of the samples contained *Microtermes*. They caused root penetration and lodging to maize in the study area. About 20% of the samples comprised *Macrotermes*, while 6.7% of the samples were *Ancistrotermes*. Samples collected from termites attacking sorghum revealed that 66.7% of the termites population were *Microtermes,* and 13.3% were *Macrotermes*.

It was known that in the past two decades, governmental and non-governmental organizations have made extensive campaigns of termite control, targeting *Macrotermes,* (Abdurahman Abdulahi, 1990) through queen removal and mound poisoning in Manasibu district. These activities probably had negatively affected the population of epigeal nest building termites, *Macrotermes,* in the area. On the contrary, subterranean termites, such as *Microtermes,* which were known for their deep and diffuse nest systems, could have probably survived disturbances due to cultivation, and apparently their population increased through time. Jones (2003) stated that control of subterranean termites has been a challenging proposition, given their small size, cryptic habits, and tenacious foraging behavior. Brooks *et al*. (2003) noted destructive nature of subterranean termites in such a way that they had been responsible for most of termite damage to cellulose material in the United States of America.

Type of termite damage to crops varied from plant to plant and was also found to depend on foraging behavior of the termites. *Microtermes* and *Ancistrotermes* were observed foraging frequently in stems and such damage was limited to maize and sorghum. Only one sample of *Microtermes* was identified from the base of the root of matured teff in Serbi site. However, no indication of foraging of this termite on teff was observed which agrees with the report of Abdurahman Abdulahi (1990). The probable explanation for absence of root penetration in teff might be thinness of stem of the crop. Stem/stalk cutting at surface level by *Macrotermes, Pseudacanthotermes* and *Odontotermes* caused severe threat to maize and teff. The later termite genus was not observed cutting sorghum stalk. Termites were also observed foraging on plants under cover of soil sheeting. This is in agreement with Cowie and Wood (1989) who reported these types of damage. *Macrotermes, Odontotermes* and *Pseudacanthotermes* were identified from soil sheeting in the rangelands. In addition, snouted termites belonging to the genus *Trinervitermes* of the subfamily Nasutitermitinae were identified from badly denuded and eroded rangelands in the present study. They were observed foraging on lower parts

of living grasses, emerging out of their galleries through narrow holes. This finding agrees with that of Hickin (1971). Newly cut grasses were observed in soil sheeting of *Odontotermes, Pseudacanthotermes* and *Macrotermes*.

Foraging by termites on outer parts of plants under soil sheeting was observed during rainy season, more frequently on sunny days. This mode of foraging increased towards the onset of the dry season. Foraging on crops under soil sheeting generally decreased in continuous heavy rains. Termites did not damage crops in wetlands, which were around riverbanks, whereas those on dry hillsides were seriously damaged (personal observation). Pearce (1997) stated that constant irrigation of crops prevented termite activities.

Maize, teff and sorghum were all damaged by termites in all of the study sites. The level of termite damage to these crops was significantly different ($P < 0.05$). Teff was the most seriously damaged crop (29.89 ± 1.16) as opposed to what was reported by Cowie and Wood (1989). They noted that the most heavily damaged crop in Ethiopia was maize. In this study, the mean percentage damage caused by termite to maize was $16.62 \pm .67$, and that of sorghum was 1.52 ± 0.05. Therefore sorghum was the least damaged of all the study crops.

In maize, teff and sorghum, the levels of termite damage in vegetative, tasseling /flowering/ heading, and maturity stages showed significant differences ($P < 0.05$). In all the crops, different trends of damage were observed at different growth stages. Less damage was observed in teff at vegetative stage and thereafter it increased sharply through flowering up to maturity stage. Damage to maize began with stem cutting at vegetative stage, and was followed by root penetration. At late vegetative stage, there was a brief period at which both root penetration and stem cutting coincided. In sorghum, maximum damage took place at vegetative stage and no new damage was observed after heading.

Marked regeneration of grasses was registered on all the three rangelands, which were protected from grazing by livestock, which could be an indication that livestock played a major role in denuded rangelands in the study area. On the other hand, the fact that number of termite foraging holes per m^2 became significantly higher in unprotected rangelands than in the protected ones revealed that foraging activity of termites increased in overgrazed rangelands. This indicated that overgrazing has likely aggravated termite damage to rangelands and the probable presence of competition between termites and livestock. When the unprotected plots of the three

rangelands were observed, the number of termite foraging holes per m^2 was found to be inversely related to the mean percentage of vegetation cover per m^2 of the plots.

In general, from the current study, it can be concluded that several genera of termites cause damage to maize, sorghum, teff and rangelands in Mansibu districts of western Ethiopia. However, the major damage was caused by the genus *Microtermes*. Hence, the control strategy on termites in the study area should target this genus especially on the most termite-susceptible crops like teff and maize. Results obtained from the rangelands study also clearly demonstrated the need of focusing on ecological management such as minimum grazing in the integrated management of termites, among others.

ACKNOWLEDGEMENTS

Our sincere thanks go to the Department of Biology and the School of Graduate Studies, Addis Ababa University for financial assistance. We are also very much indebted for all organizations and individuals who have directly or indirectly contributed to the success of this study.

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