

BIOSYSTEMATIC STUDIES OF THE TERMITE GENUS  
Odontotermes (HOLMGREN) WITH SPECIAL REFERENCE  
TO KENYA.

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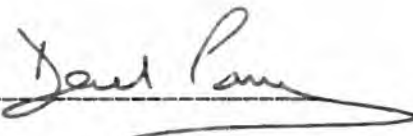
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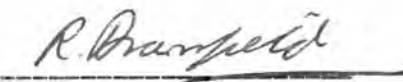
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ABSTRACT

Odontotermes is a large and diverse genus containing some species that are pests in agriculture and forestry. Work on this genus has been hampered by taxonomic difficulties. The genus has never been revised since it was erected by Holmgren in 1912. In East Africa there are thirty recorded species, more than in any other genus of termites, but most of these cannot be identified with confidence. Some of the type specimens are of alates while others are of soldiers.

All available primary types have been examined and compared with East African Odontotermes material. In the study area, Odontotermes species were divided into two groups defined by their size and shape. Species were defined by numerical taxonomy and cluster analysis on a suite of morphological measurements. In addition ecological characteristics were examined, especially the external and internal structure of the nest and the detailed sculpture of the fungus combs. By these means, ten species were distinguished, which are described and illustrated. Four species are described as "Sp. near". These species are believed to be new. An attempt has been made to key the East African Odontotermes species on the basis of the soldier caste.



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## CHAPTER ONE

INTRODUCTION1.1 The Taxonomic Context of the Genus Odontotermes

The termites (Isoptera) belonging to the family Termitidae are the most successful living termites. They are most abundant in numbers of individuals and numbers of species in the grasslands and forests of the lowland tropics. They decrease in proportion in temperate zones, in deserts and at high altitudes (Emerson, 1952). Their social life is by far the most advanced within this order of social insects. The Termitidae are grouped into four subfamilies on the basis of the morphology of the worker intestine. These are Apicotermitinae, Termitinae, Macrotermitinae and Nasutitermitinae (Sands, 1972).

The genus Odontotermes (Holmgren) belongs to the subfamily Macrotermitinae whose members are fungus-growers. Their fungus combs are dispersed in separate chambers clustered together, either with no mound showing above ground or under a wide low mound, usually with open passages leading down to it (Bagine, 1982). Among the eleven genera of the subfamily Macrotermitinae (Kemner, 1934), Odontotermes like Macrotermes and Microtermes occurs in both Africa and Asia.



It is believed to have originated in the Afrotropical Region and dispersed into the Indo-Malayan Region in the early Miocene period through Western Asia (Emerson, 1955; Krishna & Weesner, 1970, Sen-Sarma, 1974; Thakur, 1976). Of the 195 species described so far, 107 occur in the Afrotropical Region, and out of these 107 species about 30 have been recorded from East African countries (Wanyonyi et al 1984). The genus occurs in a wide range of habitats from desert to tropical rain forests, and from sea-level to altitudes well over 3000 m. In East Africa they are widely distributed except in the most arid areas and above moorland zones. Mounds of Odontotermes species are less common in cultivated areas than in uncleared areas (pers. observation). Like the majority of other termites, Odontotermes feed largely on dead and dried plant materials.

## 1.2 Economic Importance of the Genus Odontotermes

Within their habitats, Odontotermes play a significant role in the biological turnover of cellulosic materials and in the physical and chemical alteration of soils (Bagine, 1984). Odontotermes can therefore be classified as being of major economic importance. They are known to cause damage to structural timber in houses (pers. observation). They are also alleged to cause losses in agriculture, horticulture and forestry by destroying seedlings, Harris (1961).

They are reported to cause local damage to maize and other cereals before harvesting and are known to attack stored grain crops after harvest Collins (unpubl. report). However as yet there is no quantitative published information on Odontotermes damage available from Africa. In Southern Asia Odontotermes species are among the principal termites injurious to economic plants such as wheat, maize, gram, sugarcane, ground-nut, several vegetables, fruit trees, coconut palm etc. (Roonwal, 1979, 1981). The genus has been noted to have marked beneficial effects on soil formation and modification in the Kisii area, Kenya (Wielemaker, 1984).

### 1.3. THE NEED FOR REVISIONARY STUDIES OF ODONTOTERMES

Notwithstanding the economic importance of the genus, our knowledge of the taxonomy and distribution of many Odontotermes species is very incomplete and far from satisfactory. This is so partly because the genus is taxonomically difficult and partly because existing descriptions of the majority of the species are very meagre and lack illustrations. Above all, the type-specimens of most of the species being scattered in various foreign museums were not easily available to earlier workers. Some 30 Odontotermes species have been described or recorded from East Africa, but

the existing descriptions are largely inadequate for the accurate identification of species which are morphologically similar, and possess few features useful for specific identification. Serious difficulties have therefore been encountered while sorting out the current identity of a good number of species collected and studied in this region of Africa.

For example unpublished studies carried out at the British Museum of Natural History (BMNH) in London showed that one Odontotermes species from Meru in Kenya had been wrongly identified as O. fallax, simply because the type locality of O. fallax is around Mt. Meru in Tanzania. Subsequently these samples were labelled as topotypes by the earlier workers. Compared with the type series, these samples did not match at all. On the other hand, several researchers such as Kemp (1955), Glover et al (1964), Darlington (1985 and pers. comm.), who have worked in East Africa have expressed their concern as regards the taxonomy of Odontotermes, and have therefore been unable to give specific identifications for their collections.



Although the literature on Odontotermes in East Africa is very sparse, there have recently been a number of ecologically orientated projects in the region, all of which indicated the importance of the genus and some of which provide useful starting points for the current taxonomic study. For example, Kemp (1955) carried out a detailed survey of the termite fauna of North-Eastern Tanzania and recorded Odontotermes species as the most abundant termites in many of the habitats she studied. The following species were recorded: Odontotermes amanicus, O. kibarensis, O. latericius, O. sp. nr. patruus, O. rectanguloides, O. stercorivorus, O. zambesiensis, O. sp. i, O. sp. ii, O. sp. iii. More recently work on Odontotermes has been going on in different parts of Kenya, where Darlington (in prep.) has shown that in the area around Kajiado the subdominant group of termites consists of four species of Odontotermes: O. monodon, O. amanicus, O. tanganicus and O. zambesiensis. Each species has a distinctive nest structure and fungus comb.

At Ruaraka, Kenya (Rotich N.K.A. unpubl. report) distinguished three nest types belonging to the species O. nolaensis, O. kibarensis and O. stercorivorus. He also used measurements of soldier caste to separate species. At Masai Mara, some preliminary work has been done on the termites of the Mara and Loita Plains (Darlington, per comm.). The dominant termites over large areas are several species of Odontotermes

which in some places occur at very high densities. Glover et al (1964) noted the effect of Odontotermes mounds on the grassland vegetation of the Loita Plains. Bagine, (unpubl. report) working in the Mt. Kulal area, Marsabit District, described Odontotermes species as the most widespread termites foraging intensively on the limited resources of semi-arid and arid lands. The Odontotermes species included O. monodon, O. mediocris, O. boranicus, O. latericius and one unidentified species. The occurrence and the ecology of O. badius, O. zambiensis and O. mediocris was described by Buxton (1979) in Tsavo National Park.

A project sponsored by the Agricultural University, Wageningen, Netherlands, on the nature and development of soils in Kisii has shown the importance of termite activities. The dominant species are members of the genus Odontotermes (Kooyman & Onck, in prep.).

Disc-shaped mounds of large size (10 - 25m in diameter and 0.5 - 3m high) occur at high density over hundreds of square miles between 1500 and 3000m altitude in Kenya. The mounds are occupied by living termites of the genus Odontotermes. Disc-mounds have been sectioned at Oleserwa, near Kajiado and on the Embakasi plain. Surface collections (some of which included alates) have been made at the above sites and at Ngobit, Nyahururu, Ol Bolossa and Ol Kalou and Eldoret - Kapatagat (Darlington, unpubl. report).



## CHAPTER TWO

L I T E R A T U R E R E V I E W2.1 Taxonomic History of the Genus Odontotermes

The genus Termes Hagen was considered by Haviland (1898) to fall into a number of natural groups. Of these, three were old world genera of fungus-growers. "The most important represented by Termes bellicosus; it builds tall mounds, the imago and soldiers are of large size, and the latter have a transparent tip to the labrum and a toothless margin to the mandibles. The second is represented by Termes vulgaris; it builds insignificantly small mounds or none at all; the imago is large but the soldiers are of moderate size, have a few bristles at the tip of the labrum and a minute tooth at the middle of the cutting-margin of each mandible, or at any rate of the left one. The last group, represented by Termes incertus, has individuals of moderate size and quite different habit from those of the previous groups."

Holmgren (1910) erected the genus Odontotermes based on Haviland's "Section with Termes vulgaris for type". He divided the genus Odontotermes into three subgenera Odontotermes s. str. Cyclotermes and Xenotermes. However Banks & Snyder (1920); Emerson (1928, 1953; Fuller (1921, 1924) and Sjostedt (1926) continued to recognise Termes and ignored Holmgren's

Odontotermes. Kemner (1934) recognised Odontotermes as a valid taxon after Holmgren. Following him, Ahmad (1949, 1958) Chatterjee and Thakur (1964, 1970); Roonwal and Pant (1953) have retained the name Odontotermes either as a genus or as a subgenus.

Termes (with Termes fatalis L. as the type-species) belongs to the subfamily Termitinae, in which soldiers have snapping mandibles and a different shape of head-capsule in contrast with Holmgren's (1912) genus Odontotermes (with Termes vulgaris as the type-species). The soldiers of Odontotermes have sabre-shaped mandibles with a distinct tooth at various positions on the left mandible. Also the species included under the genus Termes are humivorous (Adamson, 1943; Corbett and Miller, 1936), whereas the genus Odontotermes includes essentially fungus-growing termites of the subfamily Macrotermitinae which feed on wood and other plant materials (Snyder, 1949; Sands, 1956; Lee and Wood, 1971; Thakur, 1981).

Holmgren (1912) described the subgenus, Cyclotermes, (with Termes obesus Rambur as type-species) and in 1913 a further new subgenus, Hypotermes, to replace his earlier subgenus Xenotermes Holmgren (1912) which was found to be preoccupied by Xenotermes feae Wasmann (Coleoptera:

Rhysopaussinae). In the same publication he also transferred some of the species placed earlier under Odontotermes to Cyclotermes and distinguished these two subgenera as follows:

Cyclotermes. Imago: Postclypeus half as long as wide.

Soldier: Left mandible with forwardly pointing tooth; Mandibles relatively small, delicate, sabre shaped; Head distinctly narrow in front; small species.

Odontotermes. Imago: Postclypeus less than half as long as wide.

Soldier: Left mandible with a short but not forwardly pointed tooth varying in position. Mandibles short and thick; Head; usually rectangular in mostly large species.

This presented serious difficulties in separating different species under both these subgenera. Ahmad (1949) made a thorough study of these characters and subjected the data to statistical analysis. He found that there was a complete overlap of these characters between the supposed subgenera and did not find any significant difference between them. He therefore synonymised Cyclotermes Holmgren with Odontotermes. In 1913 Silvestri erected yet another subgenus Euscaiotermes for his monotypic species Odontotermes (Euscaiotermes) primus. Later workers, Ahmad (1950, 1958) and Snyder (1949) recognised Odontotermes as a distinct genus with



the following three subgenera: (i) Odontotermes (ii) Euscaiotermes and (iii) Hypotermes. In recent years Bose (1975); Harris (1961); Roonwal (1970), Roonwal and Chhotani (1962); Sen-Sarma (1960) and Thakur (1981) have raised each of these subgenera to full generic level. In presenting my work in the succeeding chapters, I have treated Odontotermes as a full genus without including subgenera.

## 2.2. A key to the Genera of African Macrotermitinae

The following is a key to African Macrotermitinae adapted from Bouillon and Mathot (1965) and by this study.

1. Anterior margin of pronotum with two long spines; fontanelle surrounded by swelling with a spine at the front -----2
- Anterior margin of pronotum without spines; fontanelle without spine-----3
2. Mesonotum and metanotum with lateral spines directed forward; three normal castes plus intermediates; antennae with 15 to 17 segments; tip of labrum with a hyaline point more less trilobate-----Acanthotermes

- Mesonotum and metanotum without spines; two forms of soldiers; antennae with 18 to 21 segments; tip of labrum with hyaline point usually trilobate-----Pseudacanthotermes
  
- 3. Labrum with a hyaline point-----4
  
- Labrum without hyaline point-----7
  
- 4. Antennae with 13 segments; labrum elongate with convex margins; one form of soldier and one of worker-----Sphaerotermes
  
- Antennae with 15 to 17 segments-----5
  
- 5. Antennae with 15 segments; head long with parallel sides; one form of soldier and two of worker-----Synacanthotermes
  
- Antennae with 16 or 17 segments; one or two forms of soldier and two of worker-----6
  
- 6. Large species; total head length of major soldier more than 4mm; head with sides strongly converging forwards; mandibles without teeth at inner edge of medial area two forms of soldier; minor soldier with antennae and legs relatively much larger than major soldier-----Macrotermes



- Small species; total head length of major soldier less than 3mm; left mandible with several teeth at inner edge near medial area; usually one form of soldier-----Allodotermes
  
- 7. Left mandible without clear tooth at inner edge of medial area; antennae with 12 to 15 segments-----10
  
- Left mandible with one or more teeth at inner edge of medial area; antennae with 14 to 19 segments-----8
  
- 8. Left mandible with a single medial tooth not preceded by a notch; right mandible with or without a clear marginal tooth, antennae with 15 to 19 segments; usually with two similar soldier forms -----Odontotermes
  
- Left mandible with two or more teeth at the inner edge of medial area and usually preceded by a notch; right mandible with a prominent tooth-----9

9. Left mandible with two equal marginal teeth half way from the apex, first marginal tooth preceded by a shallow notch; antennae with 16 segments; head rectangular with postero-lateral corners broadly rounded; usually one form of a soldier and two of workers -----Megaprotermes
- Left mandible with several teeth at inner edge of medial area, central tooth preceded by a deep notch; antennae with 14 segments; head with sides strongly convex; one or sometimes two soldier forms and two of workers-----Protermes
10. Mandible of major soldier strongly curved at tip; two forms of soldier; antennae with 15 segments; labrum as wide as long fontanelle small but visible-----Ancistrotermes
- Mandible of major soldier weakly curved at tip; usually two similar forms of soldier; antennae with 12 segments; labrum longer than wide; fontanelle absent-----Microtermes

### 2.3 Diagnostic Characters of the Genus Odontotermes

Imago Head: headcapsule yellowish to reddish brown, broadly oval to circular; widest across the eyes. Head and body moderately to densely pilose with short and long hairs; epicranial suture absent. Eyes medium to large, semi-circular, more or less strongly bulbous. Ocelli translucent, weakly to strongly bulged, size and position variable. Fontanelle minute, weakly raised and posteromedially placed. Antennae with 18-20 segments, relative length of proximal segments variable. Clypeus: Post-clypeus swollen, Posterior margin weakly to strongly arched. Ante-clypeus whitish, narrow and pilose. Labrum almost as broad as or slightly broader than long, hairy. Mandibles: Left mandible with an apical tooth, apical slightly longer than first marginal tooth.

Thorax: pronotum flat, trapezoid, rather densely pilose, anterior margin a little elevated with or without a median notch, sides strongly convergent posteriorly; posterior margin emarginate, median T-shaped mark and two oval spots on the antero-lateral corners almost always present, sometimes indistinct. Legs slender and hairy. Femur four times as long as medial width. Tibial spurs usually 3:2:2, tarsi four segmented. Wings: Usually hyaline dark brown. Forewing longer than hind wing. Costa and subcosta fused. Radius small, fusing with costa-subcosta a little distance from the wing scale. Radial sector thick, prominent and strongly sclerotised,

running close to and parallel with costa-subcosta, unbranched median sclerotised, emanating from the basal region of cubitus; number of branches variable, depending upon the branching of cubitus; generally 3 to 11 branches: Cubitus also poorly sclerotised with 8 to 16 branches; Radial streak present or absent. Hind wings: Costa-subcosta, Radius, Radial sector, Radial streak and cubitus as in forewing. Median arising from Radial sector well outside the wing scale.

Abdomen: Elongate and hairy; cerci two-segmented and hairy.

Worker Head: whitish yellow to deep yellow brown, sub-circular to elliptical shape. Eyes and ocelli absent. Antennae with 16 to 19 segments.

Mandible as in imago.

Thorax: pronotum saddle-shaped, anterior margin weakly to deeply emarginate, posterior margin sublinear to deeply emarginate. Mesonotum narrower than pronotum, metanotum as broad as or broader than pronotum.

Legs: hairy, femur half as long as tibia, tibial spurs usually 3:2:2; tarsi four-segmented.

Abdomen: sub-globular to elongate, Cerci two-segmented and hairy.



Soldier Head: head-capsule pale yellow to castaneous brown, broadly oval to almost rectangular, always longer than broad. Fontanelle generally indistinct. Eyes and ocelli absent. Antennae with 15 to 18 segments, distal segments in some species darker than the basal segments. Mandibles: Delicately to strongly built. Left mandible always with a median tooth. Right mandible with or without median tooth. Labrum: spatulate in shape. Thorax. Pronotum: saddle shaped, broader than long; anterior margin with an imperceptible to deep median notch. Mesonotum narrower than or as wide as pronotum. Metanotum as wide as or broader than pronotum. Legs: Tibial spurs usually 3:2:2, tarsi four-segmented. Abdomen: sub-globular to elongate; moderately to densely pilose. Cerci two-segmented and hairy.

#### 2.4

#### Scope of the Study

The current work has been exploring the taxonomic orthodoxy, and the possibility of using nest characteristics and biochemical differences on Odontotermes species collected in East Africa. More specifically this study is directed towards clarification of the taxonomy of the genus Odontotermes in Kenya. The primary aim is to furnish unambiguous characters for species discrimination which will be of use to biologists and ecologists working in the region. Specific objectives are as outlined below:



- 1) To evaluate some morphological characters as potential tools for species separation and identification in Odontotermes.
- 2) To evaluate the suitability of ecological and biochemical characters for taxonomic use.
- 3) Where possible to relate the local distribution of Odontotermes species to habitat type and other environmental factors.

## CHAPTER THREE

MATERIAL AND METHODS

## 3.1 Depositories

Table 1. lists depositories of type specimens, with the type locality, authors and known distribution of the species in East Africa; Kenya, Uganda and Tanzania (Tanganyika, Zanzibar and Pemba). The types of those species marked with an asterisk (\*) have been examined and compared with other East African material. Type specimens from the British Museum (Natural History), London (BMNH, London), Natuurhistoriska Riksmuseet, Stockholm (NR, Stockholm), American Museum of Natural History, New York (AMNH, New York) and the Naturhistorisches Museum, Maastricht (NM, Maastricht), were examined. Further material was studied at the National Museums of Kenya (NMK, Nairobi), Wageningen Agricultural University, Department of Entomology and the British Museum (Natural History), London.

Table 1: A list of East African Odontotermes species and the type depositories

Species/author	Type locality	Type depositories	Other record in E. Africa
<u>O. amanicus</u> * Sjöstedt, 1925	Tanganyika–Usambara	NR, Stockholm	Kenya, Zanzibar Pemba
<u>O. amaniensis</u> * Sjöstedt, 1924a	Tanganyika Usambara (Amani)	NR, Stockholm	Kenya
<u>O. anceps</u> * (Sjöstedt, 1911)	Ethiopia	NR, Stockholm	Tanganyika, Kenya
<u>O. apollo</u> * (Sjöstedt, 1905)	Tanganyika	BMNH, London NR, Stockholm	
<u>O. aurora</u> * (Sjöstedt, 1904)	Zanzibar	MNHN, Paris	
<u>O. badius</u> * (Haviland, 1898)	South Africa–Natal	NR, Stockholm Cambridge	Kenya, Uganda Tanganyika

Table 1 continues on page 20

<u>O. boranicus</u> * Ghidini, 1937	Ethiopia	BMNH, London	Kenya, Uganda
<u>O. cafferariae</u> * (Sjöstedt, 1897)	Pemba	NR, Stockholm	
<u>O. culturarum</u> * Sjöstedt, 1924b	South Africa	NR, Stockholm	Tanganyika
	Uganda, Kenya		
<u>O. egregius</u> * Sjöstedt, 1925	Kenya-Nairobi	NR, Stockholm	
<u>O. elgonensis</u> * Sjöstedt, 1926	Kenya-Mt. Elgon	NR, Stockholm	
<u>O. fallax</u> * Sjöstedt, 1924b	Tanganyika	NR, Stockholm	Kenya
<u>O. fulleri</u> * Emerson, 1928	Belgian, Congo	AMNH, New York	Uganda, Kenya
	(Zaire (Niagara))		Tanzania
<u>O. kibarensis</u> * Fuller, 1923	Uganda - Kibara	BMNH, London	
		NR, Stockholm	Kenya
<u>O. latericius</u> * (Haviland, 1898)	South Africa	NR, Stockholm	Uganda
	Natal	MZ, Cambridge	Tanganyika
		NM, Maastricht	Kenya
<u>O. lacustris</u> *, Harris, 1960	Malawi	BMNH, London	Kenya

Table 1. continues on page 21

<u>O. mediocris</u> * (Sjöstedt, 1911)	Ethiopia	NR, Stockholm	Kenya
<u>O. microps</u> * (Sjöstedt, 1899)	Tanganyika-Tanga	ZM, Hamburg	
		NR, Stockholm	
<u>O. monodon</u> * (Gerstaecker, 1891)	Mozambique	ZM, Hamburg	Tanganyika
		NR, Stockholm	Kenya, Uganda
<u>O. montanus</u> * Harris, 1960	Kenya-Kikuyu Escarpment	BMNH, London	Tanganyika Kenya
<u>O. nolaensis</u> * Sjöstedt, 1924b	Congo (Zaire) Barica Nola	NR, Stockholm	Uganda, Kenya Tanganyika
<u>O. palmquisti</u> * (Sjöstedt, 1907)	Tanganyika- Kilimanjaro	NM, Maastricht NR, Stockholm	
<u>O. patruus</u> * Sjöstedt, 1913	Congo (Zaire) Katanga	MRAC Tervuren NR, Stockholm	Kenya Tanganyika

Table 1. continues on page 22



<u>O. ramulosus</u> (Sjöstedt, 1904)	Tanganyika	NMHN, Paris	
<u>O. rectanguloides</u> * Sjöstedt, 1924b	Congo (Zaire)	NR, Stockholm	Uganda, Kenya Tanganyika
<u>O. stercorivorus</u> * (Sjöstedt, 1907)	Tanganyika - Kilimanjaro	NR, Stockholm	Kenya
<u>O. tanganicus</u> * Sjöstedt, 1924b	Tanganyika-Tanga	NR, Stockholm	Kenya
<u>O. terricola</u> * (Sjöstedt, 1902a)	Cameroon	MNHU, Berlin	Kenya, Tanganyika
<u>O. transvaalensis</u> * (Sjöstedt, 1902b)	South Africa Orange Free State	NM, Maastricht	Tanganyika
<u>O. zambesiensis</u> * Sjöstedt, 1914	Zambia - Zambesi	BMNH, London	Tanganyika
		NR, Stockholm	Kenya.

\* - Species examined and compared with East African material.

Abbreviations for other depositories mentioned in the text are as follows: Museum National d'Histoire Naturelle (MNHN, Paris), Museum of Zoology Cambridge University (MZ, Cambridge), Zoologisches Museum (ZM, Hamburg), Musee Royal de l'Afrique Centrale (MRAC, Tervuren), Museum fur Naturkunde der Humboldt-Universitat (MNHU, Berlin), National Collection of Insects Department of Agriculture (NCIDA, Pretoria).

### 3.2 Examination of type series of East African Odontotermes species

A detailed examination of the type material and a comparative study of all East African species deposited at the BMNH, London was undertaken. The method used and taxonomic characters studied are described in chapter five. It is beyond the scope of this study to give a detailed account (including drawings, measurements and descriptions) of all the type specimens studied in various foreign museums. However a summary is given below which includes the number of type specimens and where possible mean values of their taxonomic characters measured. All measurements are in mm and distances taken are shown on page 80. Some of the type specimens examined had some body parts missing, others terribly mishandled and could not be measured during this study.

Odontotermes amanicus Sjostedt. Types: NR, Stockholm 352 (two soldiers; one imago (female); several workers and nymphs). Tanzania: Usambara.

Soldier (n=1) - head length 3.80; width 2.92; antennal foveolar distance 2.14; left mandible length 1.84; pronotum width 2.02; hind tibia length 2.24.

Head elongate pyriform, frontal ridge definite. Antennae with 17 segments. Gula broad and long. Labrum broad and rectangular. Mandible thickly built with incurved tips, both mandibles with a prominent median tooth. Pronotum saddle-shaped.

Winged Imago (n=1) - head length 2.26, width 2.36; pronotum width 2.46.

Head semi-oval from posterior to clypeal suture. Fontanelle raised. Antennae with 19 segments. Pronotum short and sub-circular, sides strongly converging towards posterior margin.

Worker (major)(n=3) - head length 1.86, width 1.84; pronotum width 1.00; hind tibia length 1.44.

Head semi-circular from clypeal suture to posterior margin.

Frons depressed and with fontanelle, epistome inflated.

Antennae with 19 segments. Pronotum with large lobes and a distinct median notch on anterior lobe.

Compared with BMNH collection, only Harris 1935 and 1937 Coll.

Nos. 97 & 233 from Zanzibar, and Kemp 1950, 1951 and 1952 Coll.

Nos. 18, 466, 467, 513 and 730 resemble type specimens.

Odontotermes amaniensis Sjöstedt. Type: NR, Stockholm

353 (three soldiers) Tanzania : Usambara 1910.

Soldier, (n=2)- head length 2.98, width 2.45; antennal foveolar distance 1.73; left mandible length 1.60; pronotum width 1.63; hind tibia length 1.80.



Head weakly pyriform tapering posteriorly. Frons with weak but definite raised carina. Antennae with 18 segments. Gula broad and cylindrical.

Mandibles strongly built and both with a prominent median tooth. Pronotum saddle-shaped.

Harris 1964 Coll. No. 492. Tanzania : Magrotto - Amani agrees with type.

Odontotermes anceps Sjöstedt. Type NR. Stockholm 374 (3 vials with several soldiers and workers) Abyssinia (Ethiopia): 1904).

Soldier (n=5) - head length 2.70, width 2.35; antennal foveolar distance 1.65; left mandible length 1.45; pronotum width 1.49; hind tibia length 1.84.

Head strongly ovate, short with no posterior corners. Frons with short grooves. Antennae with 17 segments. Gula cylindrical and narrowing at both anterior and posterior ends. Mandibles strong and broad, slightly incurved, both mandibles with a prominent median tooth. Pronotum saddle-shaped.

Only collections from Ethiopia (Harar, Alemaya, 1963) match, with type series. Those from east Africa labelled Odontotermes anceps are not genuine representatives, but resemble Odontotermes amaniensis.

Odontotermes apollo Sjöstedt. Type: BMNH, London (two female winged imagos). Kenya: Eburru.



Imago (n=2) - head length 2.0, width 2.40; pronotum width 2.92; hind tibia length 3.08. Head semi-oval from clypeal suture to posterior margin. Frons depressed and with fontanelle spot. Antennae with 19 segments. Labrum triangular. Pronotum flat, with anterior median V-shaped notch.

There are no further representatives at the BMNH, London from East Africa.

Odontotermes aurora Sjöstedt. Type: NR, Stockholm 458 (one winged imago female) Zanzibar; BMNH, London (one queen).

S. Nigeria.

Winged Imago (n=1) - head length 2.80, width 1.96; pronotum width 2.91.

Head sub-circular from clypeal suture to posterior margin contracted in front. Frons flattened. Antennae with 19 segments. Labrum elongate rectangular. Pronotum sub-circular. Wings semi-hyaline, opaque with a reddish tinge. Queen with dark integument.

There are no E. African representatives.

Odontotermes badius Haviland. Types: NR, Stockholm 354; MZ, Cambridge No. 573 (numerous soldiers, workers and Queen South Africa.

Natal. Soldier, (n=7) - head length 3.50, width 2.85; antennal foveolar distance 1.95; left mandible length 1.80; pronotum width 1.85; hind tibia length 2.28.

Head pyriform with broadly rounded posterior. Frons smooth with a yellow spot, fontanelle surrounded by small grooves. Antennae with 17 segments. Gula long and narrow with slightly undulating sides. Mandibles robust and strongly incurved, both mandibles have a prominent median tooth. Pronotum saddle-shaped with wide anterior median notch.

Worker (Major (M) n=2, Minor (m) n=2 - head length M.2.00, m 1.34, width M 1.94, m 1.30; pronotum width M 1.08, m 0.94.

Head broadly rounded posteriorly and with slightly flattened sides. Frons flat. Antennae with 18 segments in major workers and 17 in minor worker. Queen head sub-circular from posterior margin to clypeal suture. Fontanelle inconspicuous. Antennae with 19 segments. Pronotum with anterior margin straight and a small median notch; sides converging posteriorly.

Out of the 25 labelled vials examined at the BMNH, only one vial from Tanzania (Harris 1950, No. 688) compares with the type series. Many of the vials were found to contain Odontotermes kibarensis or Odontotermes monodon.

Odontotermes boranicus Ghidini. Paratype: BMNH,

London (one soldier) Ethiopia: Caschei, 1939.

Soldier (n=1) - head length 2.06, width 1.63; antennal foveolar distance 1.02, left mandible length 1.38; pronotum width 1.21; hind tibia length 1.48.

Head ovate to weakly rectangular with sides tapering anteriorly. Frons smooth and flat with minute ridge. Antennae with 18 segments. Mandibles long and slender with curving sides and smoothly incurved tips. Pronotum with anterior margin barely curved in middle. Compares with specimens from Kenya (Harris 1950 & 1952 Coll. Nos. 610 and 826) and material from Tanzania (Kemp 1951 Col. No. 459) and Uganda (Sands 1952 Coll. No. 253).

Odontotermes cafferariae Sjöstedt. Type: NR, Stockholm

(one winged imago female) Pemba.

Imago (n=1) - head length 2.32, width 2.70; pronotum width 2.32.

Head sub-circular from clypeal suture to posterior margin.

Frons area yellowish.

Antennae with 19 segments. Pronotum flat with a conspicuous median notch anteriorly.

There are no BMNH representatives.

Odontotermes culturarum Sjöstedt. Type: NR, Stockholm 395. (three soldiers); cotype: BMNH, London (soldier) South Africa: Myombo. Soldier, (n=3) - head length 3.45, width 2.70; antennal foveolar distance 1.94; left mandible length 1.71; pronotum width 1.74; hind tibia length 2.00.

Head elongated pyriform to rectangular. Frons with a carina or median papilla. Antennae with 17 segments. Gula long and broad. Mandibles robust and both with prominent median tooth. Pronotum saddle-shaped with arcuate anterior margin and a deep median notch.

All the BMNH vials from Tanzania labelled as Odontotermes culturarum were found to be close to the type series.

Odontotermes egregius Sjöstedt. Type: NR, Stockholm 459 (two winged imago males) Kenya: Nairobi. Imago (n=2) - head length 2.39, width 2.20; pronotum width 2.50; hind tibia length 2.90. Head sub-oval from posterior to clypeal suture. Frons with a large circular yellow spot with a flat insignificant elevation. Pronotum not noticeably notched. There are no representatives at the BMNH.

Odontotermes elgonensis Sjöstedt. Type: NR, Stockholm 469a (two winged imago males) Kenya: Mt. Elgon.



Imago (n=2) - head length 2.39, width 2.12; Pronotum width 2.49; hind tibia length 2.92.- Head sub-oval from posterior margin to clypeal suture, contracted triangularly in front. Fontanelle absent or very minute on a definite rounded pimple. Antennae with 19 segments. Pronotum with wide anterior median notch. Wings deeply tinged with dark brown colour. There are no representatives at the BMNH.

Odontotermes fallax Sjöstedt. Type: NR, Stockholm

377 (two soldiers & three workers) Tanzania: Mt. Meru.

Soldier (n=1) - head length 2.81, width 2.29; antennal foveolar distance 1.64; left mandible length 1.73; pronotum width 0.85; hind tibia length 1.9.

Head short, rectangular to pyriform shape. Frons smooth, flat, without a median ridge but with minute grooves. Antennae with 17 segments. Gula ribbon-like and broad. Mandible with sharp and incurved pointed tips, both mandibles with a prominent median tooth. Pronotum saddle-shaped with deep angularly cut anterior median notch.

Worker (Major) n=3 head length 1.64, width 1.62; pronotum width 0.85; hind tibia length 1.39.

Head short and broad semi-oval from posterior margin to clypeal suture. Frons flattened. Antennae with 18 segments. Labrum long and broad. Pronotum small with anterior lobe deeply notched at the middle.

None of the BMNH vials from Tanzania and Kenya labelled as Odontotermes fallax agrees with the type series.



Odontotermes fulleri Emerson. Paratype: AMNH, New York (several soldiers & workers) Zaire: Niangara. Soldier (n=3) - head length 1.75, width 1.25; antennal foveolar distance 1.01, left mandible length 1.10; pronotum width 0.39; hind tibia length 0.86. Head short, rectangular with parallel sides. Frons with median raised ridge. Antennae with 16 segments. Gula widening anteriorly. Mandibles with strongly incurved tips. Those specimens from Kenya and Tanzania labelled as Odontotermes fulleri at the BMNH, resemble the Odontotermes stercorivorus type specimens

Odontotermes kibarensis Fuller. Cotype: NR, Stockholm 400a (two soldiers) Uganda: Kibara. Soldier (n=2)- head length 3.02, width 2.35 antennal foveolar distance 1.65; left mandible length 1.53; pronotum width 1.55; hind tibia length 1.73. Head elongate pyriform. Frons slightly raised with faint sculpturing comprising a minute median carina or papilla. Antennae with 17 segments. Gula narrow, edges slightly undulant, narrowed at base. Mandible robust with moderately strong and incurved tips, both mandibles with a prominent median tooth. Pronotum saddle-shaped with large anterior median notch.

Uganda specimens labelled as Odontotermes kibarensis at the BMNH (Brown Coll. No. 1407 from Busoga and Oloya Coll. 1967 from Kampala) agree with the type series.

Odontotermes lacustris Harris. Holotype and paratype: BMNH, London (several soldiers and winged imagos, males & females) Zambia: Abercorn.

Soldier (n=4) - head length 1.45, width 1.30; antennal foveolar distance 0.94; left mandible length 1.04; pronotum width 1.09; hind tibia length 1.30.

Head sub-oval from posterior margin to clypeal suture. Frons smooth. Antennae with 15-16 segments. Gula short and broad. Labrum long and narrow. Mandible long and slender, with sharply incurved tips. Right mandible with vestigial median tooth. Pronotum saddle-shaped, anterior lobes with crenate margins.

Imagos Females (n=3) - head length 2.80, width 2.73; pronotum width 2.50; hind tibia 3.00. Head semi-circular from posterior margins to clypeal suture. Frontal area lighter than adjacent areas. Antennae with 19 segments. Pronotum with anterior lobes. Wings brown, long and broad with variable venation. Several vials in the BMNH labelled as Odontotermes latericius agree with Odontotermes lacustris (Harris 1950 Coll. No. 594, Uganda: Butiaba; Watson Coll. No. 532, Kenya: Koncheliba; Kemp 1949/52 Coll. No. 570; Tanzania: Handeni, and Hesse 1952).

Odontotermes latericius Haviland. Type: NR,

Stockholm 419; Cambridge (several soldiers, workers and imago male  
S. Africa: Natal.

Soldier (n=5)- head length 1.50, width 1.25; antennal foveolar  
distance 0.92; left mandible 0.96; pronotum width 0.97; hind  
tibia length 1.29.

Head ovate with rounded sides. Frons smooth. Antennae with 16  
segments. Gula broad, distinctly convex in cross section.

Mandibles slender and curving upwards towards the tips. Right  
mandible with vestigial median tooth. Pronotum with moderately  
bilobed anterior margin.

Winged imago (n=1) - head length 2.60, width 2.24; pronotum  
width 2.50; hind tibia length 3.24.

Head ovate. Frons and epistome conspicuously rough with  
folds. Antennae with 19 segments. Pronotum flat and  
sub-circular with concave anterior margins.

Worker (Major) (n=2) - head length 1.50, width 1.48; pronotum  
width 0.81; hind tibia length 1.29.

Head semi-oval from posterior margin to clypeal suture. Frons  
smoothly depressed in major workers. Antennae with 17  
segments. Pronotum saddle-shaped. Some vials in the BMNH  
containing labelled samples were found to be close to the type  
series : Harris 1938 Coll. Nos. 330 & 352, Tanzania : Tuduru  
and Okerewe; Kemp 1951 Coll. No. 98, Tanzania Amani.



Odontotermes mediocris Sjöstedt. Type: NR, Stockholm 431a (one soldier, two workers) Abyssinia (Ethiopia).

Soldier (n=1) - head length 1.20, width 0.96; antennal foveolar distance 0.75; left mandible length 0.80; pronotum width 0.65; hind tibia length 0.94.

Head ovate. Frons smooth. Antennae with 15-16 segments. Gula short and broadly rectangular, convex in cross section.

Mandibles slender and narrow at the tips, strongly incurved at apex. Right mandible with a vestigial median tooth.

Worker (Major (M) n=1, Minor (m) n=1 - head length M 1.50, m 0.92, width M 1.31, m 0.86; pronotum width M 0.71, m 0.56; hind tibia length M 1.10; m 0.92. Head semi-oval to semi-circular from posterior margin to clypeal suture, U-shaped. Frons smooth with 17 segments. Pronotum notched with elongated posterior lobes. Harris 1950 Coll. Nos. 823 & 683, from Mtito Andei & Voi in Kenya agree with the type.

Odontotermes microps Sjöstedt. Type: NR, Stockholm 435. (winged imago) Tanzania: Tanga. Imago (n=1) - head length 2.12, width 1.84; pronotum width 2.08; hind tibia length 2.52. Head semi-oval from clypeal suture to posterior margin. Frons area elevated with a very small punctiform depression. Antennae with 19 segments. Pronotum sub-circular. Wings brown. There are no representatives at the BMNH.



Odontotermes monodon Gerstaecker. Type: NR, Stockholm  
 349 (soldiers, two workers) Mozambique: Quelimane. Soldier  
 (n=3) - head length 3.85, width 3.14; antennal foveolar  
 distance 2.18; left mandible length 1.98; pronotum width 2.09;  
 hind tibia length 2.42. Head short and broad, generally  
 pyriform shaped. Frons flattened towards the front, and with a  
 raised rounded median carina. Antennae with 17-18 segments.  
 Gula long and rectangular. Mandibles very robust and incurved  
 at the tips. Both mandibles with a prominent median tooth.  
 Pronotum saddle-shaped with very wide notches.  
 Worker (Major) n=2 - head length 1.49, width 1.42; pronotum  
 width 0.80; hind tibia length 1.19.  
 Head semi-oval or U-shaped from posterior margin to clypeal  
 suture. Frons smooth with shallow depressions. Antennal with  
 17 segments. Pronotum with anterior lobe slightly emarginate.  
 BMNH Coll. 1950 from Tanzania: Kilimanjaro agree with type  
 series.

Odontotermes montanus Harris. Types: BMNH, London  
 (several soldiers) Kenya: Kikuyu escarpment.  
 Soldier (n=3) - head length 2.62, width 1.96 antennal foveolar  
 distance 1.50 : left mandible length 1.58; pronotum width 1.36;  
 hind tibia length 1.72.

Head elongate rectangular. Frons area slightly raised.

Antennae with 17 segments. Gula broad and cylindrical. Both mandibles having a prominent median tooth. Pronotum saddle-shaped and with large anterior lobes and distinct median notch. All 14 vials labelled Odontotermes montanus at the BMNH agree with type series.

Odontotermes nolaensis Sjöstedt. Type: NR Stockholm 402 (several soldiers) Zaire: Bonia-Nola; Cotype BMNH, London. Soldier (n=5) - head length 2.18, width 1.44; antennal foveolar distance 1.18; left mandible length 1.12; pronotum width 1.05; hind tibia length 1.15.

Head elongate rectangular. Frons smooth and slightly flattened. Antennae with 16 segments. Mandibles fairly robust, left mandibles with a prominent median tooth. Pronotum saddle-shaped. There were no morphological differences found between type specimens of Odontotermes nolaensis and Odontotermes stercorivorus. Therefore all nine vials in the BMNH labelled as Odontotermes nolaensis should be referred to Odontotermes stercorivorus.

Odontotermes palmquisti Sjöstedt. Type: NR, Stockholm 464 (two winged imagos, a male and a female) Tanzania: Kilimanjaro; Cotypes BMNH, London. Imago (n=2) - head length 2.40, width 2.30; pronotum width 2.70; hind tibia length 3.31.

Head semi-circular from posterior to clypeal suture. Frons with raised carina and an indefinite fontanelle. Antennae with 19 segments. Pronotum flat and sub-circular. Wing scale dark brown. Matches with Sands 1953 Coll. from Kenya: Bongole Balesa. Other vials labelled as Odontotermes palmquisti resemble Odontotermes monodon.

Odontotermes patruus Sjöstedt. Types: NR, Stockholm 398 (six soldiers and workers) Zaire : Katanga.

Soldier (n=4) - head length 1.56 width 2.23; antennal foveolar distance 1.67; left mandible length 1.57; pronotum width 1.49; hind tibia length 1.71.

Head rectangular with posterior corners rounded. Frons somewhat flattened, a carina scarcely visible from above. Antennae with 17 segments. Gula long and narrowing posteriorly. Mandibles robust and both with a prominent median tooth. Pronotum saddle-shaped with deeply incised anterior lobes.

Worker (major) (n=1) - head length 1.59, width 1.50; pronotum width 0.80; hind tibia length 1.18.

Head U-shaped. Frons area flat with a depression and a fontanelle. Antennae with 17 segments. Pronotum saddle-shaped. BMNH collections from Tanzania and Kenya, determined by Harris and Bacchus are close to type series.



Odontotermes rectanguloides Sjöstedt. Types: NR,  
Stockholm 347 (Several soldiers and workers) Zaire.

Soldier (n=1) - head length 2.14; pronotum width 2.22; hind  
tibia length 2.56.

Head broad rectangular, in profile the head is a flat oval.

Frons smooth and flat with a small papilla. Antennae with 17  
segments. Gula broad and narrowed posteriorly. Mandibles  
robust with short incurved tips, both mandibles with a  
prominent blunt median tooth. Pronotum saddle-shaped, anterior  
lobes large with a V-shaped median notch.

Worker (Major (M) n=2, minor (m) n=2) - head length M 1.75, m  
1.26; width M 1.82, m 1.33, pronotum width M 1.02, m 0.88, hind  
tibia length M 1.71, m 1.49.

Head broadly rounded and sub-oval from posterior margin to  
clypeal suture. Frons region with a circular depression  
enclosing the fontanelle. Antennae with 17 and 19 segments in  
minor and major worker respectively. Pronotum saddle-shaped  
with definite median notch on the anterior lobe.

None of the labelled BMNH collections from East Africa agree  
with the type series.



Odontotermes somaliensis Sjöstedt. Type: NR,

Stockholm 402 x (two soldiers) Somalia.

Soldier (n=2)- head length 2.72, width 1.40, antennal foveolar distance 1.42; left mandible length 1.60; pronotum width 1.51; hind tibia length 1.74.

Head elongate rectangular with parallel sides. Frons region raised.

Antennae with 17 segments. Mandibles long and slender with strongly incurved tips. Pronotum saddle-shaped with small anterior lobes and a shallow median notch.

There are no representatives from East Africa deposited at the BMNH, London.

Odontotermes stercorivorus Sjöstedt. Type: NR,

Stockholm 410 (several soldiers and workers) Tanzania: Kilimanjaro.

Soldier (n=3) - head length 2.04, width 1.35; antennal foveolar distance 1.07; left mandible length 1.06; pronotum width 1.01; hind tibia length 1.05.

Head elongate rectangular. Frons smooth. Antennae with 16 segments. Gula long and cylindrical. Mandibles fairly straight with incurved tips. Left mandibles with a prominent median tooth. Pronotum saddle-shape with deeply notch anterior margin.

Worker (major)(n=6)- head length 1.38, width 1.30; Pronotum width 0.67; hind tibia length 0.90.

Head semi-ovate from posterior to clypeal suture. Frons smooth with a fontanelle spot. Antennae with 17 segments. Pronotum with anterior lobes smaller than posterior lobe.

Morphologically similar to Odontotermes nolaensis. Wilkinson 1959 collection from Machakos, Kenya, differs from type series.

Odontotermes tanqanicus Sjöstedt. Type: NR,

Stockholm 406 (several soldiers and workers) Tanzania: Tanga.

Soldier (n=5) - head length 2.50, width 1.90; antennal foveolar distance 1.34; Left mandible length 1.27; pronotum width 1.22; hind tibia length 1.38.

Head pyriform to rectangular. Frons flat with small carina. Antennae with 16 - 17 segments. Gula cylindrical. Mandibles robust with strongly incurved tips. Mandibular tooth only a short distance from the tip. Both mandibles with a prominent tooth. Pronotum saddle-shaped with deep narrow anterior median notch. Worker (major) (n=1) - head length 1.40, width 1.34; pronotum width 0.74; hind tibia length 1.08.

Head semi-oval from posterior margin to clypeal suture. Frons smooth with shallow depression. Antennae segments broken. Pronotum with uprightly held anterior lobes.

The following BMNH collections were found to compare well with the type series: Kemp 1950 & 1952 collection from Tanzania: Tongoni and Gombela; Lepage 1977 Coll. No. 210 from Kenya, Harris 1935 & 1951 Colls. NOS. 98 & 761 from Zanzibar; Harris Coll. No. 423 from Tanzania: Amani; Harris 1950 and 1964 collections from Tanzania and Kenya respectively

Odontotermes terricola Sjöstedt. Type: NR, Stockholm 396 (two soldiers) Cameroon.

Soldier (n=2)- head length 1.68, width 1.75; antennal foveolar distance 1.86; left mandible length 1.66; pronotum width 1.65. Head elongate rectangular with straight sides. Frons flat and smooth. Antennae with 17 segments, relatively very small compared to body size. Gula long and rectangular. Mandibles robust and short both with prominent median tooth. Pronotum notched.

Tubes labelled as Odontotermes terricola from Tanzania

(Ngorongoro crater and Serengeti) and specimens from Kenya

Masai Mara nest No. 380 do not match with type specimens.

These BMNH samples are very small and represented by a couple of specimens.

Odontotermes transvaalensis Sjöstedt. Type: NR, Stockholm, Morphotype 373a (two soldiers) South Africa, Orange Free State : 374a (two soldiers) Uganda: Ruwenzori. Type soldiers from Orange Free State once dried out and badly mishandled hence comparison is difficult. The measurements and descriptions given below are from Ruwenzori specimens. Soldier (n=2)- head length 2.13; width 1.75; antennal foveolar distance 1.24; left mandible length 1.28; pronotum width 1.15; hind tibia length 1.56.

Head semi-oval from posterior margin to clypeal suture. Frons without a fontanelle, smooth with very minute ridge. Antennae with 16 segments. Gula short and rectangular. Mandibles, slender with incurved tips. Both mandibles with a median tooth. Pronotum saddle-shaped with very small anterior median notch. Odontotermes transvaalensis from Ruwenzori compares well with Harris 1950 Coll. No. 602 from Kenya: Timboroa.

Odontotermes zambesiensis Sjöstedt. Type : NR, Stockholm 401 (one soldier and two workers) Zambia: Zambesi; Cotype BMNH, London (one soldier and several workers). Soldier (n=1) - head length 2.28; width 1.57; antennal foveolar distance 1.23; left mandible 1.38; pronotum width 1.33; hind tibia length 1.40.



Head rectangular. Frons smooth with raised ridge. Antennae with 17 segments. Gula ribbon-like, moderately wide, lightly constricted before the middle. Mandibles slender straight and incurved. Left mandible with median tooth more prominent than the right mandible tooth. Pronotum saddle-shaped with small anterior median notch.

Worker (Major (M) n=1 Minor (m) n=1 - head length M 1.62, m 1.12, width M 1.56, m 1.06; pronotum width M 0.93, m 0.78; hind tibia length M 1.24, m 1.07.

Head U-shaped. Frons smooth and slightly raised with a small fontanelle. Antennae with 17 and 18 segments in minor and major workers respectively. Pronotum saddle-shaped.

Harris 1938 Coll. No. 355 from Tanzania: Tunduru and Mahiwa sample No. 344, all agree with type series.

### 3.3 How to recognise East African Odontotermes

Alate differs from all other genera in the Macrotermitinae by having:-

- (i) Media and Cubitus veins of forewing united at the base and not arising separately from the scale.
- (ii) Antennae with 19 segments, the third antennal segments shorter than the second.

Worker differs from all other Macrotermitinae in having :-

- (i) Head capsule and other body parts pale yellow darkening to yellowish brown in alcohol.
- (ii) Head capsule ovate to parallel-sided.
- (iii) Antennae with 16-19 segments.

Soldier differs from the other Macrotermitinae in having all the following :-

- (i) Mandibles robust, fairly straight with incurved tips.
- (ii) A distinct median tooth on the left mandible always and on the right usually.
- (iii) Labrum without a hyaline tip.
- (iv) Antennae with 15-18 segments.

Odontotermes species can be grouped into three using soldier characters. These groups include :-

- (a) 'badius' group. Large species with broad head capsule narrowing in front (total body length 7.5 - 15.0 mm). Frons with grooves or frontal ridge. Right mandible with a broad based median tooth. Head width usually exceeding 2.5 mm,

- (b) 'tanganicus' group. Medium sized species (total body length 4.5 - 9.5 mm). Head capsule broad or elongate rectangular. Right mandible usually with a definite median tooth. Head width usually under 2.5 mm.
- (c) 'latericius' group. Small species with pyriform or ovate head capsule (total body length 3.5 - 4.5 mm). Right mandible with or without a vestigial median tooth. Left mandible with a distinct median tooth whose upper edge makes an acute angle with the blade. Head width under 2.0 mm.

## 3.4

## The Study Area

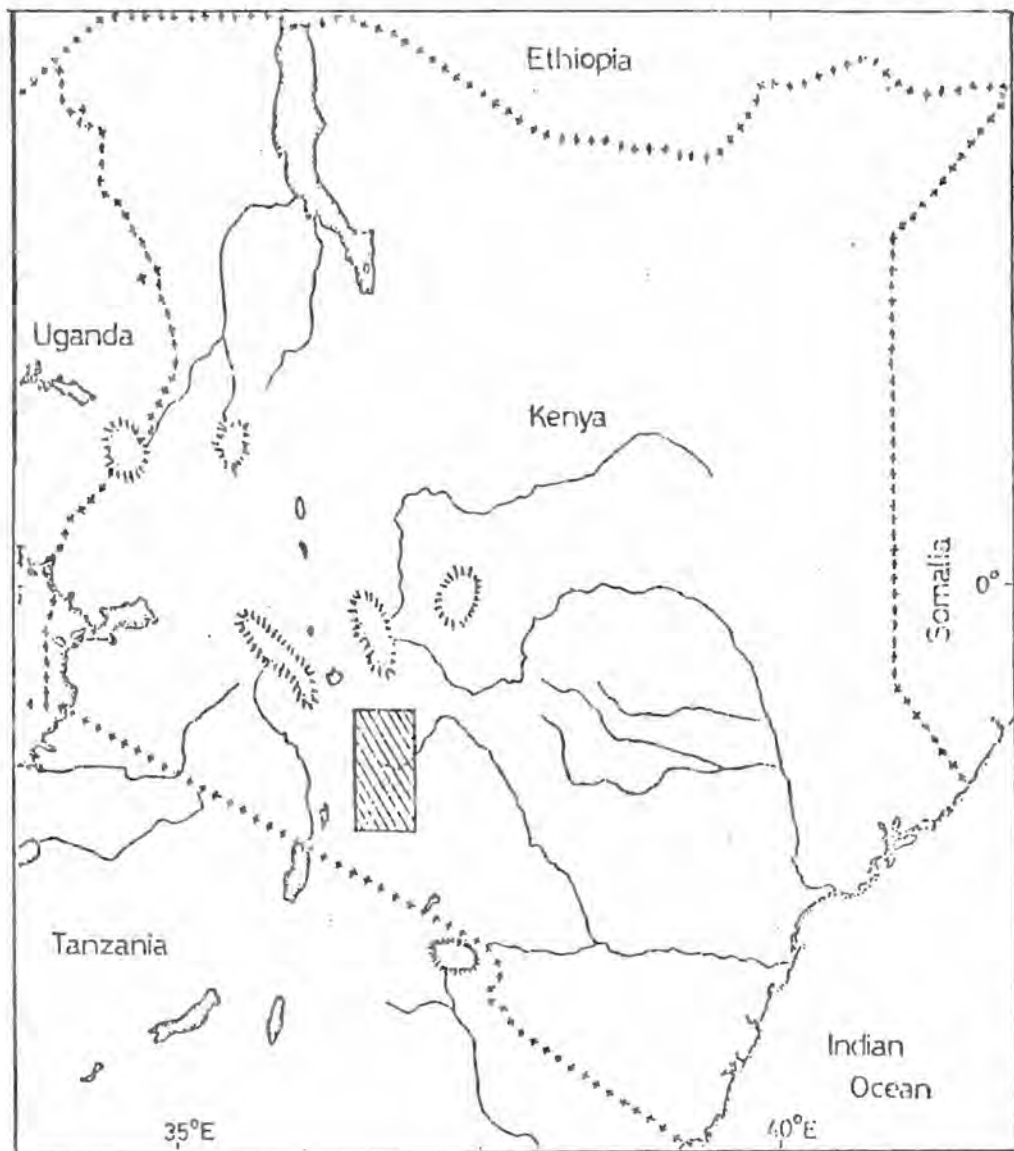
Opportunistic collections were made in various places in Kenya and Uganda, but detailed studies were made on material collected in nests within a chosen area in Southern Central, Kenya (Fig. 1) between  $1^{\circ} 00'$  and  $2^{\circ} 00'S$  and  $36^{\circ} 37'$  and  $37^{\circ} 05'E$ . This area was chosen as representative of Kenya's Odontotermes species because the fauna and flora of the area have been relatively well studied, and the area included both a range of altitudes and different vegetation types permitting a comparative study. Finally nearly all the sites are easily accessible by road from Nairobi.

The study area covers Nairobi and part of Kajiado District (Fig. 2). In the south stretch the wide expanses of the Athi and Kapiti plains and in the north the land rises to the fertile and well watered highlands, formerly densely forested and now intensively cultivated. The Rift Valley borders its western side. The vegetation types found within this study area are shown in Fig. 2.

All the study material collected within or outside the study area has been deposited in the Section of Entomology, National Museums of Kenya Nairobi (NMK, Nairobi).



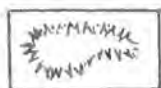
Fig. 1 MAP OF KENYA SHOWING THE LOCATION OF STUDY AREA.



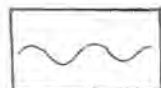
scale of kilometres

0 70 140 210 280

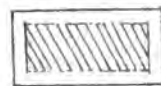
Legend:



Mountains



Rivers

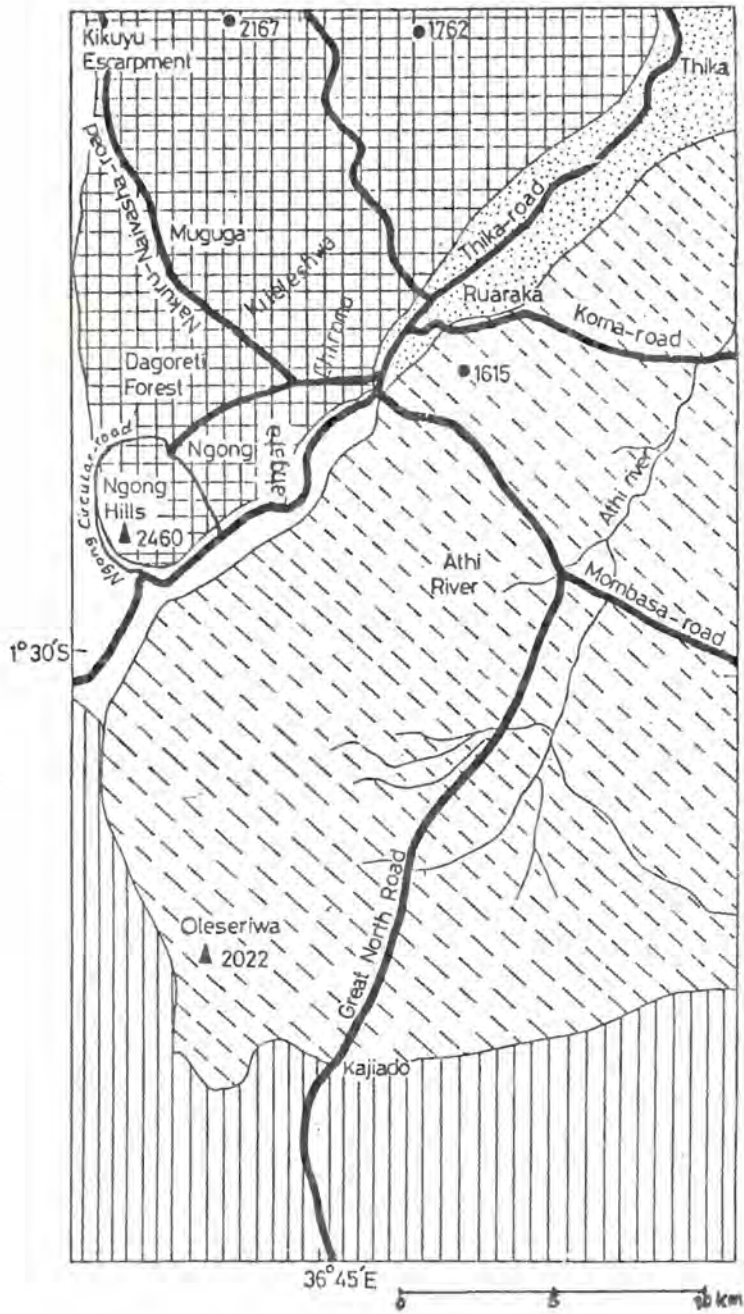


Study area









Lakes

Fig. 2. VEGETATION TYPES OF THE STUDY AREA.



Legend:

- |   |                   |   |                     |
|---|-------------------|---|---------------------|
|  | Combretum Savanna |  | Evergreen Bushland  |
|  | Grasslands        |  | Former Forest Areas |
|  | Acacia Savanna    |  | Altitude in metres  |

## CHAPTER FOUR

NEST STRUCTURE AND RELATED ECOLOGICAL ASPECTS

## 4.1. Material and Methods

A survey was made of Odontotermes species within the study area. Termites were collected from their foraging sheetings or from nests. Several nests were opened around Kajiado ( $1^{\circ} 53'S$   $36^{\circ} 30'E$ ), Ruaraka ( $1^{\circ} 14'S$   $36^{\circ} 53'E$ ), Langata ( $1^{\circ} 01'S$   $34^{\circ} 44'E$ ), Dagoretti ( $1^{\circ} 17'S$   $36^{\circ} 41'E$ ), and Muguga ( $1^{\circ} 13'S$   $36^{\circ} 38'E$ ), Limuru ( $1^{\circ} 06'S$   $36^{\circ} 37'E$ ), Ngong ( $1^{\circ} 24'S$   $36^{\circ} 45'E$ ), Kileleshwa ( $1^{\circ} 17'S$   $36^{\circ} 47'E$ ), Chiromo ( $1^{\circ} 16'S$   $36^{\circ} 48'E$ ) and Oleserewa ( $1^{\circ} 02'S$   $36^{\circ} 38'E$ ) (Fig. 2). Ecology of mounds surrounding vegetation and soil were studied and specific altitudes of nest sites recorded. Vegetation was divided into five habitat zones while soil types was described upon its colour and texture characteristics. Three soil types were noted (Table 2).

External features of the mounds were described and internal structures of those opened were studied. The external mound basal diameter was measured using a tape measure or estimated by pacing accurately across the mound area. Where

Table 2: Ecological distribution of Odontotermes species in the study area

SPECIES NAME	LOCALITY	SOIL TYPE			VEGETATION TYPE					ALTITUDE (M)
		Red loam	Black /grey clay	Sandy	Forest Area	Ever-green bush	River-ine	Open grass land	Culti-vated land	
<u>O. amaniensis</u>	Chiromo Dagoretti Muguga Kilelesha	*			*				*	1680-2150
<u>O. sp.nr. badius</u>	Dagoretti Muguga		*					*		1650-2100
<u>O. kibarensis</u>	Ruaraka Kajiado Langata Chiromo	*	*			*	*		*	1550-1750
<u>O. sp.nr. monodon</u>	Kajiado	*	*			*				1650
<u>O. montanus</u>	Muguga Limuru Ngong Chiromo Oleserewa	*			*				*	2000-2250
<u>O. nolaensis</u>	Langata Ngong Dagoretti Ruaraka	*	*			*	*	*		1750-2100
<u>O. patruus</u>	Muguga Limuru	*		*		*			*	1980
<u>O. stercorivorus</u>	Kileleshwa Chiromo Langata Ruaraka	*		*				*	*	1650-1800
<u>O. sp.nr. tanganicus</u>	Kajiado	*	*			*		*		1650
<u>O. sp.nr. zambesiensis</u>	Kajiado	*	*			*		*		1650

\* = presence of Odontotermes species



open air passages were present, their diameters were measured. If air passages or chimneys were present in the mounds, their numbers were noted.

Internal structures were studied by digging a trench approximately 0.5m wide across the middle of the mound area (see for example Plate 1). The trenches were dug from known nests within the study area using digging tools such as mattocks, shovels and picks. Fungus chambers and termites were sampled along this trench. Fungus chamber dimensions (i.e. depth, length and height) were measured. The internal structures noted were chambers, air passages and fungus combs. Fungus combs were carefully removed from their chambers and taken to the laboratory to be dried at room temperature before being stored in boxes. Three separate groups of fresh samples were taken, the first two groups comprising soldiers, major and minor workers and alates if present. The third sample was composed of soldiers only. The first sample was used for description and body measurements, while the second sample was dried in open petri-dishes for dry weight records. The third sample was used for biochemical analysis. During field collection termites were placed in tubes filled with 70% alcohol either in the field or after removal from fungus combs back in the laboratory.

Plate 1. An exposed nest of Odontotermes nolaensis showing internal features, fungus combs (circle) distributed across the nest, (rectangle) enclosing an empty chamber, Ruaraka site.



## 4.2 Observations and Results

### 4.2.1 General Description of Odontotermes Mound Structures

Odontotermes species build a considerable variety of mounds or nests and many of them are conspicuously well vegetated even when alive. Some Odontotermes nests are significantly larger than Macrotermes nests (Darlington 1984). Some mounds are more than five times wider than their height and form lenticular or disc mounds. These disc mounds are common features of some African Odontotermes e.g. Odontotermes kibarensis. Nests of some species have fungus chambers which are dispersed within the nest, similar to Macrotermes species (Darlington 1985a) and many of these produce neither mound nor air shafts. The only surface indication of the nest is the seasonal eruption of flight holes. Flight activity in Odontotermes species usually takes place during or just after heavy rain.

In general Odontotermes mounds may measure from 1 to 15m in diameter and 0.25m to 3m high. Mounds may contain open or sealed holes (Plate 2) which range in numbers from zero to well over 100. Open holes from 1cm to 0.3m in diameter are common features of Odontotermes mounds. In some cases holes may have raised rims of crumbly soil. The nests are deeply buried and difficult to dig into without a pick axe.

Plate 2. An Odontotermes kibarensis mound, a typical example of external features of Odontotermes mounds, Kajiado site.



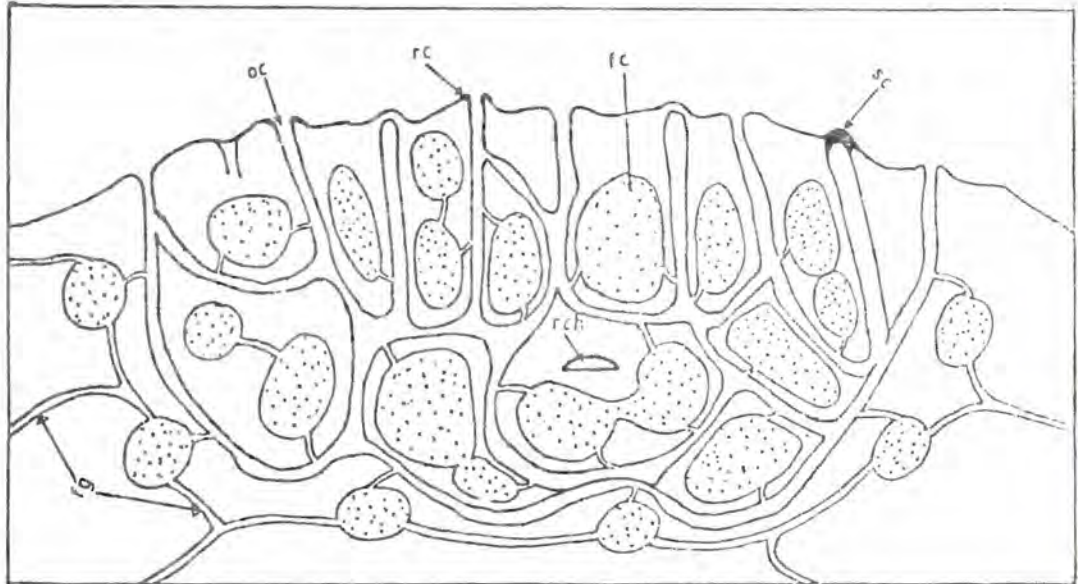


The typical nest of Odontotermes is quite centralised with fungus chambers clustered under a rather insignificant mound of irregular shape, with vertical air shafts of circular section running down between the chambers (e.g. Grasse and Noirot, 1950, Hartwig, 1966). See also the example in Fig. 3. The fungus combs are contained in chambers which differ in their diameters (probably due to their age or size of the fungus combs) but usually with the larger ones located at the middle of the nest or near the royal chamber. These fungus combs contain eggs and young larvae besides soldiers and workers.

The royal chamber is a discrete cavity with a flat oval floor and an arched roof. Its inside is smooth, and is marked by numerous small holes, each leading out to a passage way for the entry and exit of soldiers and workers. It contains a king and one or more large physogastric queens. Usually no discrete nurseries are found but larvae are present in small masses either in the fungus combs or scattered elsewhere in the nest.

Eleven different types of Odontotermes mounds were found within the study area (see section 4.2.2. page 58). Some were raised and had open holes or sealed holes, others were below the level of the soil surface and had open or sealed holes. Field records of various Odontotermes species and their surrounding features such as vegetation, soil and altitude are shown in Table 2.

Fig. 3 A SKETCH DRAWING OF A CLASSICAL ODONTOTERMES NEST.



KEY:

- fc - Fungus-comb chamber
- fg - Foraging galleries
- oc - Open chimney or air passage
- rc - Rimmed chimney
- rch- Royal chamber
- sc - Sealed chimney or air passage

Specimens collected from termite colonies in the study area were compared with type specimens and if they matched, the appropriate species name was used. However, if they were found to be close but differing consistently the name was qualified by "near" (nr.). For example Odontotermes sp. nr. tanganicus (see section 2) from Kajiado has been wrongly identified as Odontotermes tanganicus at the BMNH. The type series, (soldier caste) has slight but consistent differences in the general morphology from the BMNH specimens. In addition, the tooth position on the inner edges of the mandibles is different. Odontotermes tanganicus (type specimens) has its tooth located on the distal side 0.39 mm from the mandible tip (n=5), while that of Odontotermes sp.nr. tanganicus is located almost at the middle of the mandible 0.49 mm from the tip (n=10).

#### 4.2.2. Mounds Built by Odontotermes species in the Study Area

Odontotermes amaniensis. Number of nests sampled: two; fungus chambers examined: 10. Mounds are generally slightly raised (10 cm to about 50 cm) above the ground level and usually have a few large open chimneys. The number of holes ranges from three to ten while their diameter is between 15 and 150 mm. The top of the mound is usually vegetated with grasses. The nest contains large chambers containing fungus combs and termites.



Some soldiers have whitish abdomens which may be due to age or other factors. When molested they usually eject a whitish substance which turns brownish and sticky as it dries. Plate 3 shows the structure of a fungus comb from an Odontotermes amaniensis nest.

Odontotermes sp. nr. badius. Number of nests sampled: two, fungus chambers examined: 23. Heights of mounds above the soil surface vary, ranging from 50 cm to about 125 cm in riverine vegetation. They have large open chimneys with diameter ranges of between 50 mm to 250 mm. Mounds are vegetated with shrubs, herbs, grasses and sometimes small trees. Fungus chambers are large with average dimensions of 40 x 30 cm wide and height of 25 cm and located close to the air passages inside the nests. Fungus combs appear granular and whitish brown, and have holes ranging from 1.5 to 12 mm in diameter. The fungus comb contains layers (Plate 4). Soldiers are aggressive and eject a brownish defense secretion when molested which stains when dry.

Odontotermes kibarensis. Number of nests sampled: six; fungus chambers examined: 71. This species builds two type of mounds which are raised above the ground level. They range from 10 cm to about 100 cm in height. One type forms a conical shape mound which has open air passages at the side and at the



Plate 3. Fungus combs from an Odontotermes amaniensis  
nest.



Plate 4. Fungus combs from an Odontotermes sp. nr.  
Badius nest.



top (Plate 5a). The average diameter is about 1 - 2m. The other is a 'disc' type which is wide with several holes at the middle of the mound (Plate 5b) and may measure from 8m in diameter. Both types are characterised by grasses, herbs and shrubs growing on top. The chimneys are usually rimmed with crumbled soil. Their diameters are between 4 and 159mm and they range from 10 to 50 in number. The fungus chambers are scattered within the mound with the larger ones located towards the middle. The smaller ones have average dimensions of 10 x 10 x 10cm while large ones are up to 50 by 30cm wide and 35cm high. The fungus combs are dark grey to whitish grey. Their layers are firmly jointed together forming an irregular oval-shape. Some fungus comb holes are shallow, others deep (Plate 6). Holes range from 1 -11mm in diameter, and their entrances are roughly lined with granules.

Odontotermes sp. nr. monodon. Number of nests sampled: one; fungus chambers examined: 934. This species builds very extensive flat mounds about 1,000cm in diameter, with large chimneys which are usually rimmed and above the ground surface. Mounds are vegetated with shrubs, herbs, grasses and sometimes large trees. Some air passage holes are open, others sealed (Plate 7) with diameters of 10 to 220mm.



Plate 5a. A conical type mound built by  
Odontotermes kibarensis Ruaraka site.



Plate 5b. A disc type mound built by Odontotermes kibarensis, with open (rectangle ) and closed (circle) air passages, Ruaraka site.



Plate 6. Fungus combs from an Odontotermes kibarensis nest.





Plate 7. An Odontotermes sp. nr. monodon mound in herb/shrub and grass vegetation, air passages with rimmed entrances (arrows), Kajiado site.



Fungus chambers are scattered all over the nest, and contain massive fungus combs. Fungus chamber dimensions range from 4 x 4 cm wide and 3 cm in height to 50 x 48 cm and 41 cm in height. Fungus combs are made of black, white and brownish granules. Fungus comb holes are many and close to each other with thick walls between. The outer cells have thin and wide walls which contain large entrances averaging 30 mm in diameter. The layers underneath have compact walls and small shallow holes measuring an average of 3 mm in diameter (Plate 8).

Odontotermes montanus. Number of nests sampled: four; fungus chambers examined: eight. Mounds of this species are inconspicuous and only visible during rainy seasons. This is the period when termites are actively involved in construction and swarming of alates. Usually mounds cover a wide area approximately 5 m across. When active they construct small holes usually with a raised rim which are often sealed. Mounds are covered by grasses or are built between growing trees. The air passage holes join around massive fungus combs, enclosing nurseries and a royal chamber. This fungus chamber has dimensions of about 65 x 55 wide cm and 50 cm in height. The fungus combs have loosely fitted layers and thin walls. They are grey brown with wide protruding entrances. The entire fungus comb has an irregular shape (Plate 9), with holes ranging between 1.5 to 25 mm in diameter.



Plate 8. Fungus combs from an Odontotermes sp. nr. monodon nest.



Plate 9. Fungus combs from an Odontotermes montanus nest.



Soldiers have whitish abdomens and eject whitish defence substances when molested.

Odontotermes nolaensis. Number of nests sampled: three; fungus chambers examined: 103. Mounds are dome - shaped and usually with small holes which may or may not be opened, numbering from five to twelve. The diameter of mounds range from 0.75-2 m and may be 1 m high. Shrubs, herbs and sometimes grasses grow on top (plates 10a and 10b). Fungus chambers are of medium size with dimensions from 4 x 4 cm wide and 4 cm in height to 15 x 20 cm wide and 18 cm high. They are scattered within the nest. The chambers take the oval or circular shape of the fungus comb. Fungus combs are whitish grey with sculptured surfaces. Their holes are not well defined having their entrances raised (Plate 11).

Odontotermes patruus. Number of nests sampled: two; fungus chambers examined: 5. Mounds of this species are slightly raised above the ground surface and similar to those of O. amaniensis. They range from a few cm to 50 cm in height. They are usually vegetated with herbs and grasses. Mounds contain about eight large open passages with an average diameter of 140 mm. Fungus chambers are large and contain grey coloured fungus combs with strong walls. Fungus comb holes are close to each other and of various sizes. Their widest diameters range from 1.5 mm to 9 mm (Plate 12). Soldiers eject a brownish sticky defense substance when molested.



Plate 10a. A dome-shaped Odontotermes nolaensis mound, with dense vegetation growing on top, Langata site.



Plate 10b. An Odontotermes nolaensis mound with almost bare soil on top and tiny holes (circles), Ruaraka site.





Plate 11. Fungus combs from an Odontotermes nolaensis nest.



Plate 12. Fungus comb from an Odontotermes patruus nest.



Odontotermes stercorivorus      Number of nests sampled: four; fungus chambers examined: 44. Mounds of this species may be raised or level with the ground surface. Their heights range from 5 cm to about 60 cm. They are characterised by several small open air passages and a few sealed ones (plate 13). Grasses, herbs and sometimes shrubs grow on top of the mounds. Fungus chambers are small and distributed all over the nest. They are usually close to each other and have dimensions from 0.8 x 1.5 cm and 0.9 cm in height to 13 x 14 cm and 11 cm in height. Fungus combs are small and spherical in shape. Those mounds occurring in red soil have a yellow-brown fungus comb and those in black/grey cotton soil appear grey. The outer surfaces of the fungus combs do not have holes but instead furrow-like structures (Plate 14). Well defined holes appear at the bottom of the fungus combs.

Odontotermes sp.nr. tanganicus.      Number of nests sampled: five; fungus chambers examined: 1580. Mounds are raised above the ground surface. They measure about 100 cm to 175 cm in height. They contain about four to eight small open air passages with or without rimmed entrances.



Plate 13. An Odontotermes stercorivorus mound, open (rectangle) and closed (circle) air passages, Ruaraka site.



Plate 14. Fungus combs from an Odontotermes stercorivorus nest.





Some holes are usually sealed (Plate 15). Herbs and grasses grow on top of mounds. Internal galleries are connected to each other with scattered fungus chambers between (plate 16). Fungus chamber dimensions range from 1.9 x 1.9cm and 2.6 cm in height to 20.5 x 20.5 and 21.2 cm in height. Fungus comb is roughly constructed and has a cone-shaped appearance with its upper surface having shallow oblong pits and smooth sides (Plate 17). Internal structure is characterized by small to medium sized holes.

Odontotermes sp.nr. zambesiensis. Number of nests sampled: three, fungus chambers examined: 210. Mounds of this species cover an extensive area on the ground being about 10 m in diameter. Mounds are never raised but contain air passages with dome-shaped seals, scattered across the entire nest (plate 18). Mounds are usually covered with grasses and herbs and may sometimes have trees growing on them. Oval fungus chambers are scattered inside the nests. Their dimensions range from 2 x 2.5 cm and 28 cm in height to 57 x 30 cm and 57 cm in height. The fungus combs range in size also, the largest ones occurring in the middle of the nest. They are brownish with overhanging flanges on top of each other. Each layer is joined by pillar-like structures from inside (Plate 19).

Plate 15. An Odontoermes sp. nr. tanganicus mound, Kajiado site.



Plate 16. Internal features of an Odontotermes sp.nr. tanganicus.

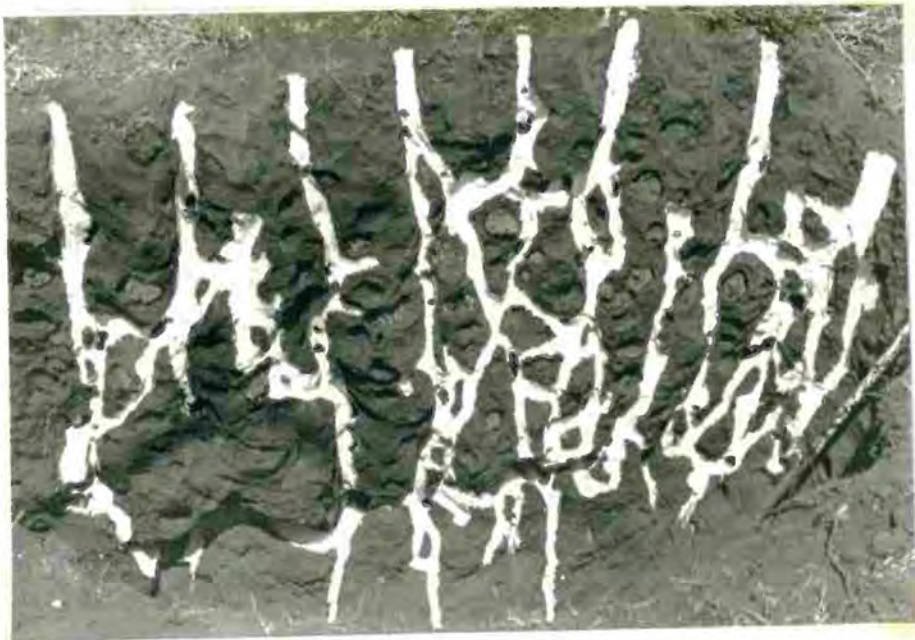




Plate 17. Fungus combs from an Odontotermes sp. nr.  
tanganicus nest.



Plate 18. Inconspicuous but extensive mound of Odontotermes  
sp. nr. zambesiensis with flight holes (circle),  
Kajiado site.



Plate 19. Fungus combs from an Odontotermes sp. nr.  
zambesiensis nest.





## 4.3

## D i s c u s s i o n

In East Africa the most common mound-building species are included in the following genera, Cubitermes, Macrotermes, Odontotermes, Pseudacanthotermes and Trinervitermes. Odontotermes mounds are of medium to large size, characterised by open or closed air passages leading into the nest. However, not all the Odontotermes species are mound builders. For example O. mediocris is a subterranean species occurring in semi-arid grassland. Nests of some Odontotermes species are usually buried below the ground surface except where the soil is water-logged. Odontotermes mounds built in water-logged clay soil are usually higher than those built in red soil. This is probably due to an adaptation to the surrounding environment. Termites will probably need to move up more soil to raise their nest above the water-table resulting in a larger mound, see for example plates 5a and 5b built by Odontotermes kibarensis in two different types of soil.

Several of the species are capable of withstanding the pressures of intensive cultivation and may become pests of standing crops. For example Odontotermes montanus; and Odontotermes stercorivorus are common in cultivated areas in Kenya. Harris (1956) considered that termite mounds represented an equilibrium of three "forces" - behaviour, material and climate. He suggested that a species

which is restricted in its distribution to a particular ecological niche or zones where environmental factors such as soil and climate are relatively uniform, will build mounds of a uniform shape. On the other hand, a species occurring in a wider range of habitats will build mounds of variable appearance. The mounds built by Odontotermes sp. nr. zambesiensis or Odontotermes sp. nr. tanganicus are examples of uniform mound building and those built by O. kibarensis exhibit a range of appearance within the study area (see Section 4.2.2).

The size of the nest is quite often characteristic of the species. For example the nests of O. nolaensis are usually much larger than those of O. stercorivorus. However, closely related species from the "badius" group i.e O. sp. nr. badius, O. kibarensis and O. amaniensis have similar mounds (Plate 2) and in most cases they can only be separated through external measurements of mound structures and the internal features of their nests. Fungus chambers and fungus combs vary in structure and texture between species ( see Plates 4, 11 and 19),

Probably the fungus chambers vary due to: (a) size and age of the nest colony. For example in Ruaraka, young nests of Odontotermes kibarensis have similar nest structure to

those of old Odontotermes stercorivorus which is morphologically smaller than O. kibarensis. In addition young nests tend to have their royal chamber near the soil surface even in deep soils, while in the older nest the royal chamber is usually buried in the soil, (b) availability of food and success of foraging strategies applied by foragers and (c) soil and climatic factors. These may have some effects on the size and shape of the chambers.

The nests built on shallow soils often have smaller fungus combs than those built in deep soils (personal observation). Similarly fungus combs vary in their colour and size and this is perhaps due to the type of plant material taken or soil particles used by workers to cultivate fungus combs.

## CHAPTER FIVE

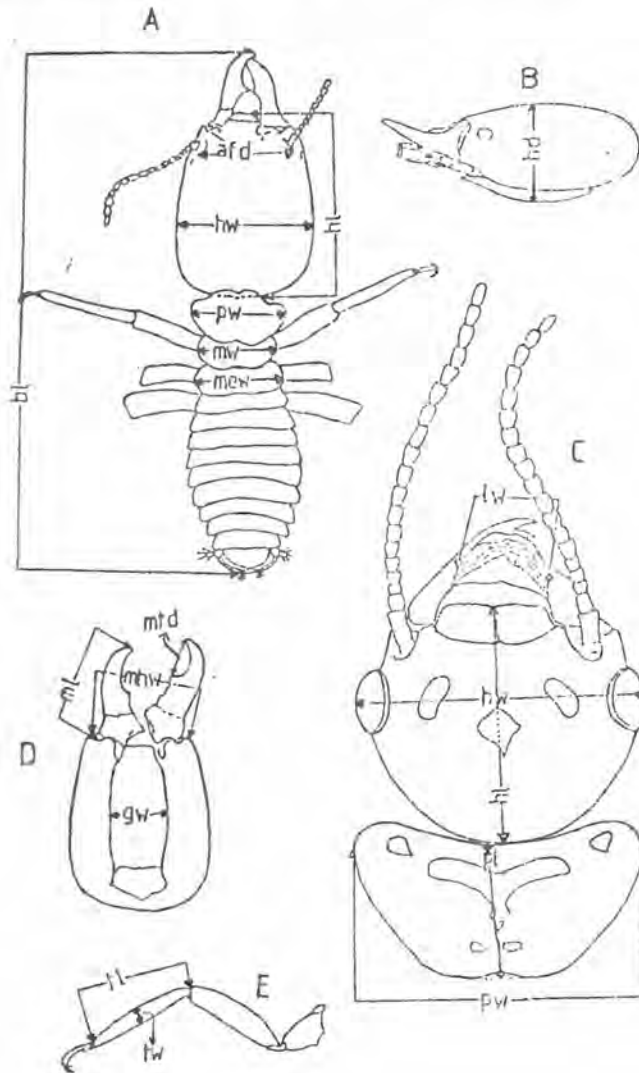
MORPHOLOGICAL AND NUMERICAL DESCRIPTIONS OF ODONTOTERMES

## 5.1 Material and Methods

Many individual termites comprising of soldiers, workers and alates (when present) were examined from different nest colonies. Descriptions and drawings of their body parts especially soldiers were made under a camera lucida. 10 - 20 soldier termites from each of 27 mature nests were measured. Samples were randomly selected from a larger sample pool by transferring them to a petri dish with soft forceps. Soldier termites usually exhibit more characters of taxonomic value than other castes and therefore more emphasis was laid on them than either workers or alates. Alates are difficult to collect except during the swarming season. All measurements of termites were made under a Wild M5A stereo microscope attached to a 1.25 camera lucida. Termites were immersed in 70% alcohol in a small petri-dish containing a plastazote ring with notches for fixing the termites, with fine hooked pins. To obtain measurements for various parts of the body (Fig.4) eyepiece graticule readings were converted into millimetre readings, using a stage micrometer. About 15 characters from each soldier termite and five characters from each worker termite were measured (see tables 3-66).



Fig. 4. DRAWINGS OF ODONTOTERMES SHOWING PARTS OF THE BODY MEASURED



KEY:

- |                                  |                               |
|----------------------------------|-------------------------------|
| A - Soldier dorsal view          | B - Soldier head profile      |
| C - Alate dorsal view            | D - Soldier head ventral view |
| E - Soldier hind leg             |                               |
| afd - Antennal foveolar distance | mhw - Minimum head width      |
| bl - Body length                 | ml - Mandible length          |
| gw - Gula width                  | mtd - Mandible tooth distance |
| hd - Head depth                  | mw - Mesonotum width          |
| hl - Head length                 | pl - Pronotum length          |
| hw - Head width                  | pw - Pronotum width           |
| lw - Labrum width                | tl - Tibia length             |
| mew - Mentanotum width           | tw - Tibia width              |

Numerical data obtained from body measurements were analysed using various techniques. Simple statistical calculations were made on the data to get the sample mean ( $\bar{x}$ ), standard deviation (SD) and coefficient of variability (CV) of each character measured in samples from different nest colonies. The range of the data was recorded. The data from closely related species were subjected to principle components analysis (See chapter 6).

## 5.2 Results

### 5.2.1 Morphology of Odontotermes species.

Morphological features of closely related Odontotermes species show few taxonomic characters but shape, size and position of some of the body parts are usually diagnostic in soldier castes. Figs.5a - 14d are all of soldier termites. The descriptions of these are given in sections 5.2.2. Two groups of Odontotermes species were recognised on the basis of their body size differences, head shape and mandibular features. These groups are "the badius" group and "the tanganicus" group, the latter being smaller. Species in the "badius" group are morphologically similar and difficult to distinguish from each other on the basis of their body size. The succeeding section gives detailed descriptions and drawings of soldier castes from every species collected in the study area.

### 5.2.2. Description of Odontotermes species of the Study Area

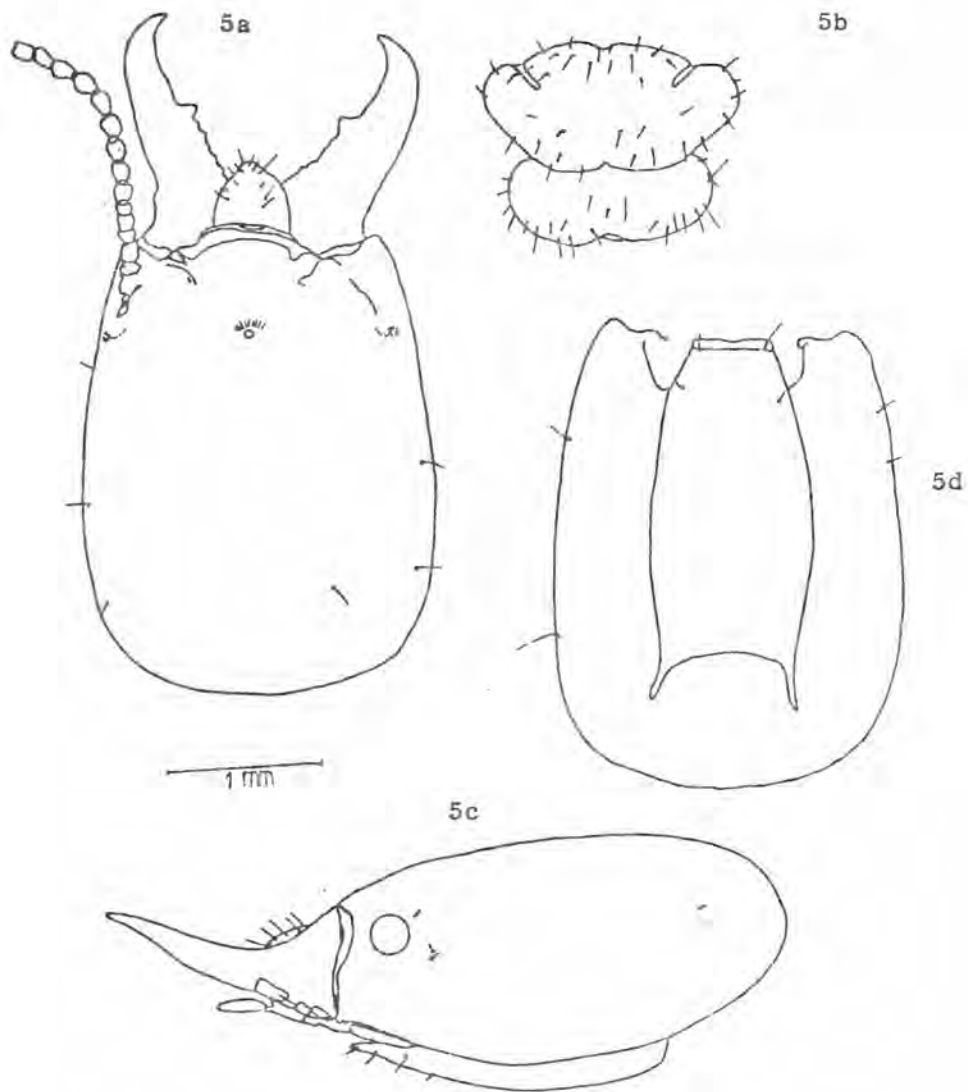
#### Odontotermes amaniensis Sjostedt

Study area nest colonies: - Chiromo

Muguga. Soldier and worker

(Fig. 5a - 5d)

DESCRIPTION. Soldier. Total body length range 7.8 to 9.5 mm. (n=34). Head subrectangular, posteriorly tapering. Frons with definite raised carina. Hair scarce. Eye spots present. Antennae with 17-18 segments, III shortest when antenna has 17 segments and IV shortest when 18 segments. Gula broadly rectangular, setae concentrated anteriorly. Labrum spathulate, with rows of long bristles. Mandibles strongly built with incurved tips. Both mandibles with a median tooth. Left tooth slightly obtuse, right tooth strongly obtuse (Fig. 5a). Mandible bases moderately hairy.



Figs. 5a - 5d. Morphology of Odontotermes amaniensis soldier caste.

5a - head capsule, dorsal view

5b - pronotum and mesonotum

5c - head, profile

5d - postmentum (gula)



Thorax hairy; pronotum with deep anterior notches, hairs distributed along the pronotum edges. Ratio of mesonotum width to pronotum width 0.70 to 0.85. Tibial spurs 3:2:2.

Head yellowish to reddish brown. Antennae pale proximally to yellow brown distally. Gula yellowish to reddish along edges; labrum yellowish. Mandibles black to dark reddish at bases. Thorax brownish yellow, abdomen yellowish, tergites darker than sternites. Measurements are given in tables 3 - 4.

Workers. Major and minor. Head rounded and moderately hairy. Fontanelle conspicuous, postclypeus raised. Antennae of major worker with 18 segments, minor worker 17 segments. Labrum tongue-shaped. Pronotum with raised anterior lobes. Head pale brownish yellow, postclypeus darker than adjacent areas. Antennae pale brown proximally to dark brown distally. Labrum reddish to yellowish. Rest of body yellowish white. Measurements are given in tables 5 - 8.

Affinities: Odontotermes amaniensis is most closely allied to Odontotermes patruus on the basis of general shape and in particular the morphology of the gula which in both species is broad medially. The morphometrics of these species do overlap. However in O. amaniensis the head capsule is conspicuously narrowed anteriorly while in O. patruus it is not.

Table 3: Body measurements of *Odontotermes amaniensis*, soldier caste, Chiromo nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	18	18	18	18	18	18	18	18	18	18	18	18
Range	2.37-3.13	1.86-2.37	1.32-1.66	0.90-1.07	1.35-1.65	0.57-0.70	1.33-1.60	0.60-0.73	1.32-1.70	1.27-1.70	1.53-1.80	0.18-0.24
Mean	2.92	2.22	1.56	1.02	1.55	0.63	1.53	0.69	1.64	1.58	1.74	0.22
SD	0.17	0.10	0.07	0.05	0.06	0.03	0.06	0.03	0.12	0.10	0.07	0.01
CV	5.90	4.75	4.81	4.82	4.11	4.26	3.85	4.18	7.52	6.15	4.14	6.92

Table 4: Body measurements of *Odontotermes amaniensis*, soldier caste, Muguga nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	16	16	16	16	16	16	16	16	16	16	16	16
Range	2.92-3.17	2.08-2.47	1.50-1.70	0.95-1.07	1.60-1.72	0.60-0.70	1.55-1.70	0.70-0.80	1.62-1.88	1.50-1.72	1.77-2.00	0.22-0.27
Mean	3.04	2.32	1.63	1.02	1.63	0.66	1.60	0.74	1.76	1.66	1.91	0.25
SD	0.09	0.10	0.07	0.04	0.04	0.02	0.04	0.02	0.07	0.06	0.06	0.02
CV	2.90	4.40	4.10	3.75	2.18	3.87	2.40	3.03	4.03	3.58	3.15	6.49

Table 5: Body measurements of Odontotermes amaniensis, major workers, Chiromo nest colony

	HEAD CAPSULEE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.67-1.13	1.60-1.67	0.27-0.47	0.73-1.00	1.07-1.33
Mean	1.96	1.66	0.36	0.91	1.28
SD	0.15	0.01	0.05	0.07	0.09
CV	7.68	0.90	15.18	824	6.88

Table 6: Body measurements of Odontotermes amaniensis, minor workers, Chiromo nest colony

n	19	19	19	19	19
Range	1.00-1.33	1.07-1.20	0.33-0.47	0.67-0.87	1.00-1.07
Mean	1.26	1.11	0.39	0.77	1.01
SD	0.11	0.04	0.06	0.05	0.03
CV	8.55	3.60	15.36	6.62	2.49



Table 7: Body measurements of Odontotermes amaniensis, major workers, Muguga nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.67-2.07	1.40-1.67	0.20-0.47	0.67-1.00	1.00-1.33
Mean	1.91	1.56	0.31	0.83	1.20
SD	0.13	0.09	0.07	0.12	0.12
CV	6.60	5.62	20.88	14.80	9.99

Table 8: Body measurements of Odontotermes amaniensis, minor workers, Muguga nest colony

n	22	22	22	22	22
Range	0.7-1.47	0.67-1.13	0.20-0.53	0.33-0.80	0.33-1.20
Mean	1.23	1.02	0.37	0.69	0.94
SD	0.21	0.15	0.08	0.13	0.24
CV	16.79	14.48	22.10	18.97	25.36

Odontotermes sp. nr. badius

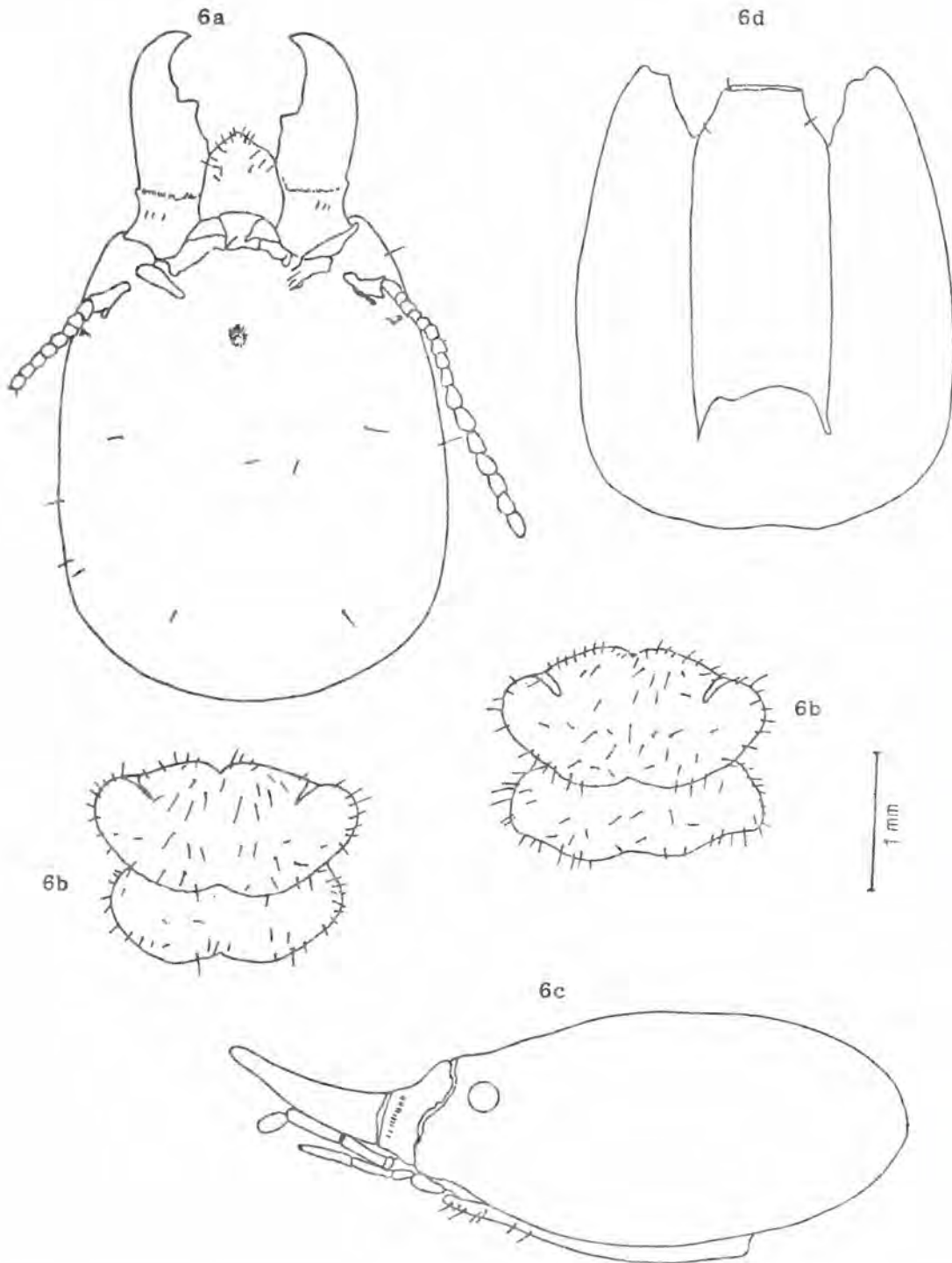
Study area nest colonies:-

Dagoretti, Muguga, Soldier, Worker and winged Imago.

(Figs. 6a - 6e)

DESCRIPTION. Soldier. Monomorphic. Total body length range 9.2 to 12.0 mm (n=31). Head elongate oval, anterior lateral margins narrowed, posterior corners constricted. Hairs long and scarce. Frons usually with small papilla and a pale spot. Above the papilla is a shallow sulcus on the raised frons. Eye spots conspicuous. Antennae with 17 to 18 segments. When there are 17 segments, III is almost the same size as V and when there are 18 segments IV is the shortest. Gula almost rectangular, lateral margins on anterior end emarginate, anterior part sculptured and with a few setae. Labrum spatulate and rounded anteriorly and having many long bristles.

Mandibles robust and strongly curved. Both mandibles with a prominent median tooth on their inner edges, that on the left being larger with its upper edge perpendicular to the axis of the mandible (Fig. 6a). Mandible edge below tooth uneven but without distinct denticles. Right mandible tooth broad with upper edge at an obtuse angle to the inner margin of the mandible. Mandibular bases with long scattered hairs. Thorax moderately hairy. Pronotum with distinct anterior lobes.



Figs. 6a - 6d. Morphology of Odontotermes sp.nr. badius soldier caste:

6a - head capsule, dorsal view

6b - pronotum and mesonotum

6c - head capsule, profile

6d - gula

Anterior margins with a definite median notch. Lateral margins rounded, posterior margin excised. Mesonotum and metanotum shorter than broad, margins wavy. Tibial spurs 3:3:2, third spur on mid tibia being reduced to a slender spine. Rest of body moderately hairy. Head red to reddish yellow, clypeal region darker than rest of the head capsule. Eye spots dark. Antennae pale red, basally to brownish distally. Gula reddish and labrum reddish orange. Mandibles black with reddish bases. Rest of body pale reddish yellow. Measurements are given in tables 9 - 10.

Workers. Major and minor. Head with lateral margins straight and broadly rounded posteriorly. Frons flattened fontanelle spot on a depressed area. Postclypeus convex with a median line, anteclypeus triangular. Eye spots present and transparent. Antennae with 19 segments in major worker, III shortest. Minor worker with 17-18 segments, when 17 segments III is shortest and when 18 segments IV is shortest. Labrum broadly tongue shaped the part behind the anterior portion heavily sclerotised, bristles scattered about the middle portion. Pronotum moderately hairy, anterior lobes held upright and lateral notches narrowed. Minor worker with pointed and broadly rounded posterior lobes. Posterior margins notched. Tibial spurs 3.3.2. The rest of the body hairy. Head reddish yellow. Labrum reddish brown with hind portion yellowish orange; mandibles red-orange with black teeth on inner edges. Pronotum pale yellow orange. Rest of body pale yellow. Measurements are given in tables 11 - 14.



Table 9: Body measurements of Odontotermes sp.nr. badius, soldier caste, Dagoretti nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	3.53-3.80	2.87-3.10	1.87-2.03	1.08-1.30	1.83-1.93	0.67-0.83	1.80-1.92	0.73-0.80	2.05-2.17	2.00-2.17	2.17-2.30	0.28-0.33
Mean	3.64	2.94	1.98	1.18	1.87	0.70	1.84	0.76	2.11	2.04	2.24	0.30
SD	0.07	0.07	0.05	0.06	0.03	0.02	0.04	0.02	0.03	0.05	0.04	0.01
CV	2.05	2.38	2.61	5.13	1.69	2.55	1.90	3.18	1.59	2.45	1.55	3.56

Table 10: Body measurements of *Odontotermes* sp.nr. *badius*, soldier caste, Muguga nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	16	16	16	16	16	16	16	16	16	16	16	16
Range	3.27-3.60	2.58-2.98	1.73-2.00	1.08-1.20	1.70-1.90	0.65-0.72	1.70-1.85	0.73-0.83	1.93-2.18	1.87-2.04	2.03-2.30	0.27-0.30
Mean	3.45	2.81	1.88	1.16	1.82	0.68	1.78	0.78	2.06	1.94	2.20	0.28
SD	0.11	0.11	0.08	0.03	0.06	0.03	0.05	0.03	0.07	0.07	0.07	0.02
CV	3.17	4.07	4.27	2.94	3.03	3.70	2.53	3.50	3.55	3.40	3.36	5.66

Table 11: Body measurements of *Odontotermes* sp. nr. badius, major workers, Dagoretti nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	2.00-2.53	1.80-2.00	0.33-0.70	1.07-1.27	1.33-1.67
Mean	2.33	1.97	0.46	1.16	1.53
SD	0.14	0.06	0.10	0.06	0.12
CV	6.02	2.79	21.66	5.37	7.88

Table 12: Body measurements of *Odontotermes* sp. nr. badius, minor workers, Dagoretti nest colony

n	20	20	20	20	20
Range	1.47-1.67	1.20-1.33	0.33-0.67	1.00-1.00	0.93-1.33
Mean	1.64	1.31	0.49	1.00	1.29
SD	0.07	0.04	0.10	0.00	0.09
CV	4.47	2.80	19.46	0.00	7.18

Table 13: Body measurements of *Odontotermes* sp. nr. *badius*, major workers, Muguga nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.60-2.40	1.60-1.93	0.27-0.67	0.67-1.13	1.13-1.67
Mean	2.08	1.84	0.46	0.94	1.45
SD	0.19	0.07	0.12	0.17	0.13
CV	9.22	3.77	25.39	18.40	8.63

Table 14: Body measurements of *Odontotermes* sp. nr. *badius*, minor workers, Muguga nest colony

n	20	20	20	20	20
Range	1.13-1.67	1.17-1.33	0.33-0.67	0.73-1.00	1.00-1.40
Mean	1.36	1.26	0.42	0.90	1.29
SD	0.15	0.07	0.08	0.11	0.09
CV	1.76	5.18	20.00	0.91	6.98



Imago. Winged male and female. Head oval, hairs long slender and dense. Fontanelle conspicuous, slightly raised, adjacent areas depressed. Frons rough and furrowed. Clypeus convex. Eyes large and circular. Ocelli large and oval. Antennae with 19 segments, III shortest. Labrum broad tongue-shaped. Pronotum with a V-shaped anterior median notch, anterior margin straight, corners rounded. Lateral margins converging to short posterior margin and posterior margin constricted and with striations. Head reddish-brown. Frons dark, ante-clypeus whitish. Eyes dark grey. Antennal segment brown and wings reddish-brown.

Affinities: Odontotermes sp. nr. badius is probably closely related to O. kibarensis with which it shares the characteristic of markings on the frons. It is distinguished by its smoothly rounded posterior margin of the head capsule. It is also closely related to Odontotermes badius, but can be distinguished by its elongate head capsule and sculptured frons which are lacking in Odontotermes badius.

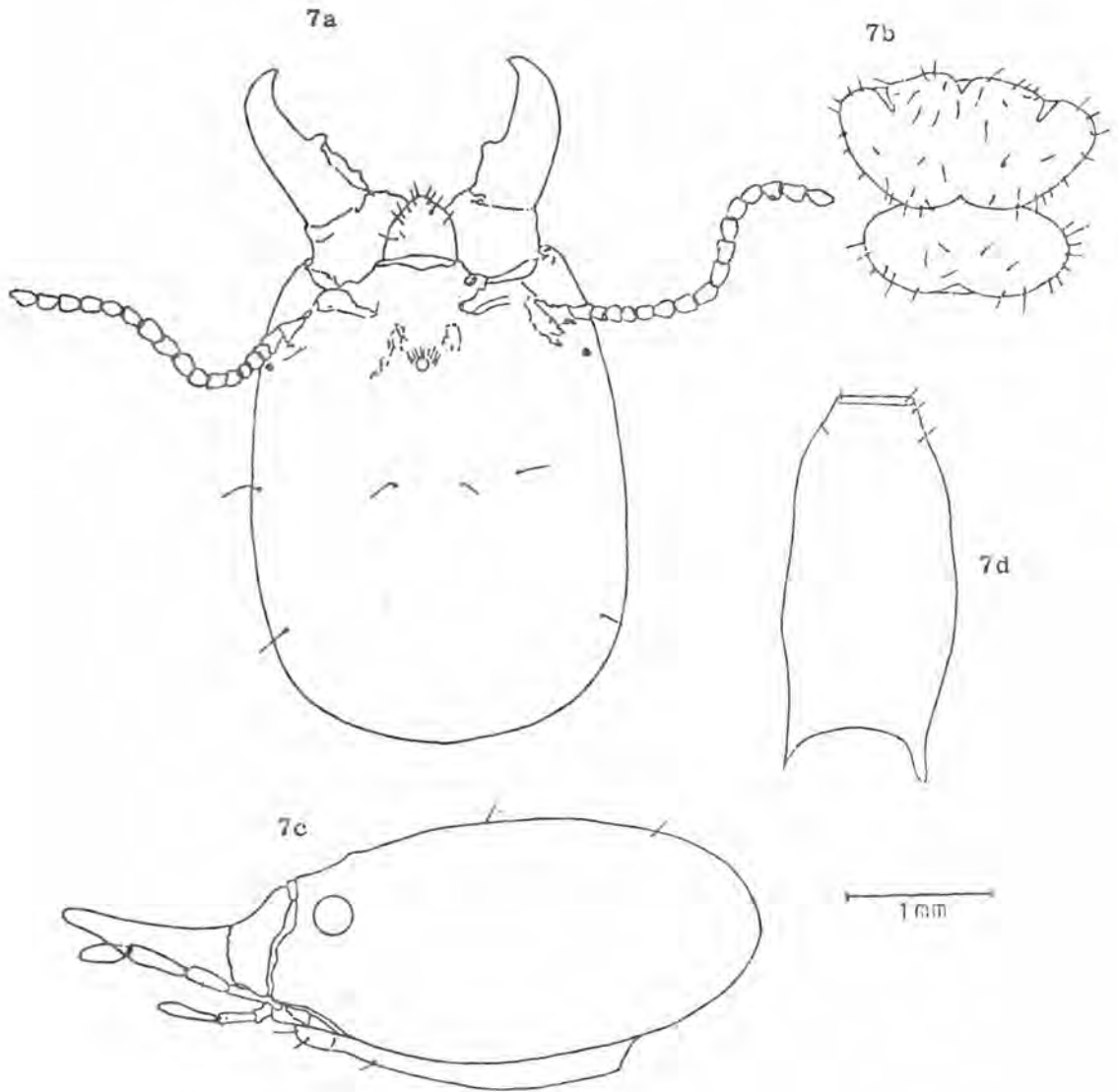
Odontotermes kibarensis (Fuller)

Study area nest colonies - Ruaraka, Chiromo and  
Kajiado. Soldier, Worker and Imago.

(Figs. 7a - 7d)

DESCRIPTION. Soldier. Total body length range 7.7 to 11.2 mm (n = 122). Head elongate and plainly narrowing towards the front, smoothly rounded posteriorly. Hairs sparse. Frontal area shallowly and broadly depressed in clypeal region. Behind clypeal region usually raised with a faint sulcus and a short carina. Some individuals with frons smooth. Eye spots small but distinct. Antennae with 17 segments, III shortest, V shorter than IV and VI which are almost equal in length. Gula narrow, edges slightly undulant, narrowed at base, anterior corners convex. Labrum with long hairs towards tip.

Mandibles short and robust, about half the head capsule length. Both mandibles with median teeth, that on the left having its upper edge nearly at right angles to the mandibular axis, while that of the right tooth forms an obtuse angle ( Fig. 7a). Left mandible with rough edge below the tooth, and a small tooth-like prominence near the base. Pronotum with distinct anterior lobes well divided by anterior median



Figs. 7a - 7d. Morphology of Odontotermes kibarensis soldier caste:

7a - head capsule, dorsal view

7b - pronotum and mesonotum

7c - head, profile

7d - gula

sulcus, posterior margin excised. Legs with prominent tibial spurs (3:2:2). Rest of body hairy. Head reddish yellow. Antennae pale proximally becoming yellow brown distally. Labrum medially yellowish and laterally transparent. Mandibles black with dark reddish bases. Rest of body pale yellow. Measurements are given in tables 15 - 22.

Worker. Major and minor. Head of major worker with broadly rounded posterior margin. Minor with narrowly rounded posterior margins. Antenna of major worker with 17-18 segments, and minor 17 segments. Pronotum with large anterior lobes and a small median sulcus, posterior edge only slightly excised. Head orange yellow with vertex paler and the epistome slightly darker with a fine dark median line. Antennae pale basally to dark brown distally. Measurements are given in tables 23-30.

Imago. Winged male and female. Head circular with scattered long hairs and numerous short ones. Fontanelle region usually raised with two conspicuous spots. Clypeus usually convex, ante-clypeus with sclerotised bands. Eyes circular, ocelli large and oval. Antennae with 19 segments, III the smallest. Pronotum broad, with numerous short hairs, lobes large, anterior margin slightly excised at the middle. Head dark red to reddish brown. Fontanelle lighter. Eyes dark grey, wings reddish brown.

Affinities. Odontotermes kibarensis is most closely allied to Odontotermes sp.nr. badius.



Table 15: Body Measurements of *Odontotermes kibarensis*, soldier caste, Ruaraka nest Colony one

	HEAD CAPSULE				MANDIBLES							
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	3.18-3.58	2.38-2.77	1.63-1.93	1.08-1.23	1.67-1.80	0.63-0.70	1.67-1.77	0.71-0.78	1.75-2.00	1.68-1.95	2.00-2.17	0.24-0.33
Mean	3.33	2.61	1.80	1.15	1.74	0.67	0.71	0.75	1.92	1.78	2.10	0.29
SD	0.10	1.10	0.08	0.05	0.04	0.02	0.03	0.02	0.07	0.07	0.06	0.02
CV	3.10	3.64	4.22	3.90	2.37	2.92	2.00	3.09	3.48	3.71	2.90	8.44

Table 16: Body measurements of *Odontotermes kibarensis*, soldier caste, Ruaraka nest Colony two

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH
n	17	17	17	17	17	17	17	17	17	17	17	17
Range	3.07-3.53	2.27-2.80	1.67-1.97	0.98-1.23	1.63-1.77	0.63-0.69	1.57-1.75	0.70-2.03	1.56-1.83	1.56-1.83	1.83-2.03	0.23-0.30
Mean	3.35	2.62	1.81	1.15	1.68	0.66	1.65	0.74	1.87	1.76	1.99	0.27
SD	0.15	0.13	0.08	0.07	0.03	0.02	0.04	0.02	0.08	0.07	0.06	0.02
CV	3.46	5.10	4.72	6.21	2.01	3.08	2.51	3.19	4.08	3.81	3.10	6.30

Table 17: Body measurements of *Odontotermes kibarensis*, soldier caste, Ruaraka nest colony three

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	13	13	13	13	13	13	13	13	13	13	13	13
Range	3.13-3.62	2.37-2.83	1.70-1.97	1.15-1.33	1.67-1.83	0.62-0.70	1.62-1.78	0.70-0.78	1.78-2.03	1.70-1.95	1.87-2.17	0.23-0.30
Mean	3.34	2.61	1.83	1.21	1.73	0.61	1.68	0.73	1.91	1.78	2.05	0.27
SD	0.14	0.13	0.07	0.05	0.06	0.12	0.05	0.02	0.08	0.17	0.10	0.02
CV	4.10	4.78	4.12	4.29	3.26	20.34	2.88	3.35	4.14	9.37	5.02	7.43

Table 18: Body measurements of *Odontotermes kibarensis* soldier caste, Langata nest Colony

	HEAD CAPSULE				MANDIBLES							
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	3.12-3.72	2.50-2.83	1.70-1.93	1.10-1.30	1.72-1.83	0.63-0.70	1.67-1.78	0.70-0.77	1.83-2.03	1.72-1.93	1.97-2.13	0.25-0.28
Mean	3.38	2.62	1.78	1.17	1.77	0.66	1.73	0.75	1.92	1.82	2.02	0.27
SD	0.14	0.07	0.06	0.05	0.03	0.02	0.03	0.02	0.05	0.07	0.04	0.02
CV	4.03	2.95	3.37	4.24	1.88	3.39	1.88	2.80	2.37	3.65	2.18	5.50



Table 19: Body measurements of *Odontotermes kibarensis*, soldier caste, Kajiado nest colony one

	HEAD CAPSULE				MANDIBLES							
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	3.20-3.53	2.53-2.80	1.75-1.95	1.13-1.25	1.60-1.80	0.57-0.65	1.61-1.73	0.65-0.73	1.83-2.00	1.67-1.84	1.93-2.13	0.27-0.30
Mean	3.37	2.67	1.82	1.18	1.73	0.62	1.70	0.70	1.92	1.77	2.03	0.27
SD	0.09	0.09	0.06	0.03	0.05	0.02	0.04	0.02	0.06	0.06	0.06	0.01
CV	2.70	3.32	3.02	2.64	2.94	3.84	2.18	3.01	3.07	3.28	2.85	4.48

Table 20: Body measurements of *Odontotermes kibarensis*, soldier caste, Kajiado nest colony two

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PROMOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	3.23-3.63	2.55-2.87	1.80-2.00	1.08-1.20	1.67-1.80	0.63-0.72	1.62-1.77	0.68-0.80	1.82-2.02	1.73-1.92	1.95-2.10	0.27-0.32
Mean	3.41	2.68	1.88	1.14	1.72	0.68	1.69	0.74	1.91	1.83	2.01	0.28
SD	0.11	0.08	0.06	0.03	0.04	0.03	0.04	0.03	0.07	0.05	0.05	0.02
CV	3.10	3.17	2.96	2.89	2.45	3.69	2.52	3.92	3.47	2.63	2.50	6.77

Table 21: Body measurements of *Odontotermes kibarensis*, soldier caste, Nairobi University ground nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PROMOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	3.00-3.50	2.27-2.75	1.57-1.87	1.03-1.18	1.58-1.80	0.53-0.67	1.57-1.75	0.62-0.75	1.63-1.95	1.60-1.88	1.83-2.10	0.23-0.30
Mean	3.26	2.54	1.72	1.10	1.72	0.61	1.68	0.70	1.82	1.76	1.98	0.26
SD	0.16	0.16	0.09	0.05	0.07	0.04	0.06	0.04	0.11	0.09	0.10	0.22
CV	4.77	6.37	5.51	4.11	4.14	6.57	3.55	5.51	5.80	4.94	4.85	8.63

Table 22: Body measurements of *Odontotermes kibarensis*, soldier caste, Kajiado mountains nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH WIDTH	GULA LENGTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PROMOTUM WIDTH	HIND TIBIA LENGTH	HIND WIDTH
n	17	17	17	17	17	17	17	17	17	17	17	17
Range	3.07-3.38	2.30-2.69	1.65-1.85	1.03-1.23	1.60-1.72	0.60-0.66	1.51-1.68	0.67-0.73	1.75-1.95	1.63-1.80	1.83-2.07	0.22-0.32
Mean	3.24	2.54	1.75	1.14	1.68	0.62	1.64	0.70	1.85	1.73	1.96	0.24
SD	0.08	0.09	0.06	0.05	0.02	0.02	0.04	0.02	0.05	0.05	0.06	0.02
CV	2.51	3.57	3.27	4.20	1.05	3.61	2.48	2.96	2.63	2.91	2.86	9.57



Table 23: Body measurements of Odontotermes kibarensis, major workers, Ruaraka nest colony one

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	2.07-2.20	1.33-1.73	0.33-0.40	0.80-1.00	1.20-1.33
Mean	2.07	1.65	0.36	0.93	1.32
SD	0.05	0.08	0.03	0.08	0.04
CV	2.67	4.70	9.23	8.36	2.66

Table 24: Body measurements of Odontotermes kibarensis, minor workers, Ruaraka nest colony one

n	20	20	20	20	20
Range	1.40-1.53	1.00-1.20	0.33-0.50	0.67-0.80	1.00-1.20
Mean	1.45	1.13	0.37	0.77	1.09
SD	0.06	0.05	0.04	0.04	0.06
CV	4.26	4.25	11.83	5.13	5.40

Table 25: Body measurements of Odontotermes kibarensis, major workers, Ruaraka nest colony two

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	26	26	26	26	26
Range	1.93-2.47	1.67-1.87	0.33-0.67	1.00-1.13	1.33-1.53
Mean	2.14	1.81	0.52	1.06	1.48
SD	0.15	0.06	0.08	0.06	0.09
CV	7.16	3.56	16.20	5.29	6.15

Table 26: Body Measurements of Odontotermes kibarensis, minor workers, Ruaraka nest colony two

n	20	20	20	20	20
Range	1.33-1.60	1.13-1.27	0.33-0.53	0.80-1.20	1.07-1.33
Mean	1.44	1.19	0.44	0.82	1.18
SD	0.13	0.04	0.06	0.16	0.07
CV	9.22	3.57	14.06	20.14	6.30

Table 27: Body measurements of Odontotermes kibarensis, major workers, Langata nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	2.40-1.80	1.67-1.93	0.20-0.53	0.80-1.00	1.07-1.47
Mean	2.18	1.78	0.33	0.98	1.35
SD	0.15	0.06	0.07	0.06	0.13
CV	6.96	3.45	19.81	6.29	9.47

Table 28: Body measurements of Odontotermes kibarensis, minor workers, Langata nest colony

n	20	20	20	20	20
Range	1.27-1.60	1.13-1.27	0.33-0.60	0.73-1.00	0.80-1.33
Mean	1.47	1.22	0.42	0.87	1.14
SD	0.12	0.05	0.07	0.08	0.13
CV	7.97	4.06	16.37	9.14	11.06

Table 29: Body measurements of Odontotermes kibarensis, major workers, Kajiado nest colony one

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.80-2.33	1.60-1.73	0.33-0.60	0.80-1.07	1.07-1.47
Mean	2.10	1.68	0.39	0.95	1.34
SD	0.12	0.04	0.07	0.077	0.07
CV	5.68	2.19	17.31	7.89	5.56

Table 30: Body measurements of Odontotermes kibarensis, minor workers, Kajiado nest colony one

n	20	20	20	20	20
Range	1.33-1.60	1.13-1.27	0.33-0.47	0.73-0.87	1.00-1.27
Mean	1.43	1.16	0.36	0.78	1.07
SD	0.08	0.04	0.04	0.04	0.09
CV	5.34	3.37	11.04	4.65	8.22



Odontotermes sp. nr. monodon

Study area nest colonies: - Kajiado.

Soldier, worker and imago

(Figs 8a - 8d)

DESCRIPTION. Soldier. Total body length range 9.9 to 13.9 mm (n= 26). Head elongate, sub-oval, broad posteriorly and narrowing in front. Hairs few and scattered. Frons flattened towards the front and with grooves (Fig.8a). Median carina with a yellowish spot and depressed anteriorly. Between the antennal sockets and frons region are punctiform depressions noticeable when viewed from above. Clypeus small and flat. Antennae with 17-18 segments. In individuals with 17 segments, IV is exceptionally large, III and V are almost equal in size. In individuals with 18 segments, IV is the shortest. Two basal segments are smooth and without hairs. Gula long and rectangular with excised anterior lateral margins and a few setae on anterior portion. Labrum with long bristles on the middle position.

Mandibles robust, bases with a few long hairs and striations. Both mandibles incurved at the tips and with median teeth. Left tooth being stronger with arcuate edges. (Fig. 8a). Below the tooth, the inner margins of the mandible

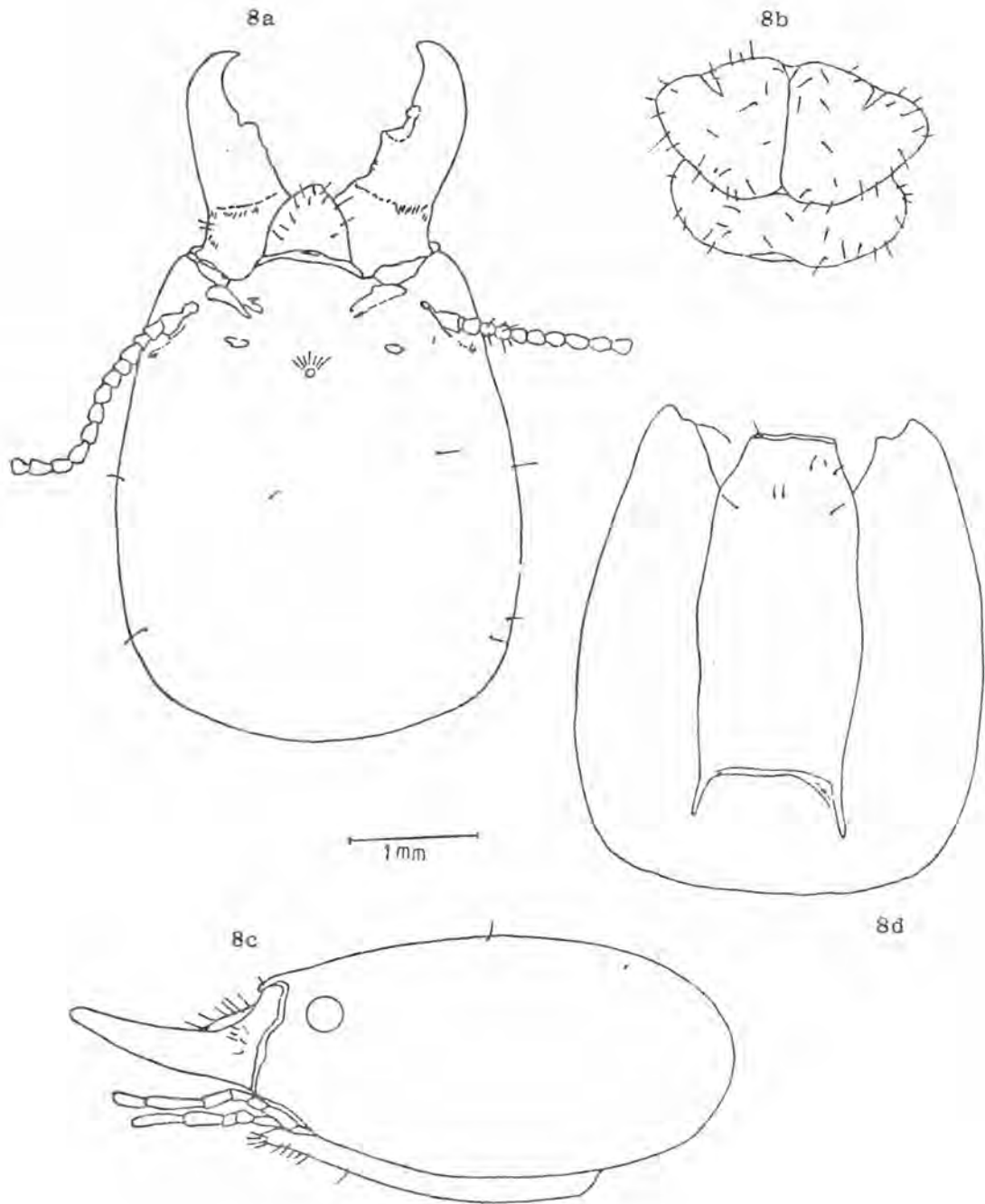


Fig. 8a - 8d. Morphology of Odontotermes sp.nr.monodon soldier caste:

8a - head capsule,dorsal view,

8b - pronotum and mesonotum

8c - head,profile

8d - gula

usually with denticles. Right mandible tooth with its upper edge at an obtuse angle to the mandibular axis. Thorax moderately hairy. Pronotum strongly notched with anterior margin nearly straight. Hairs sparse. Mesonotum and metanotum long, narrow and flat. Tibial spurs 3:2:2. Rest of body moderately hairy. Head reddish-yellow. Eye spot black. Antennal segments reddish brown. Gula reddish. Mandibles dark red to red at bases. Thorax yellowish darkening in alcohol. Abdominal segments yellowish. Measurements are given in table 31.

Workers. Major and Minor. Head sub-circular, hair moderately dense. Frons smooth, below epistome flatly depressed. Postclypeus convex, raised and with median line. Major worker with 18-19 antennae segments, when 18 segments III and IV are not completely separated, IV the shortest, where 19 segments present III is the shortest. Minor worker with 17-18 segments, when 17, III and V are almost equal and when 18 segments IV is the shortest. Labrum broadly spatulate with long bristles. Posterior part narrowing with straight margins. Mandibles with a few hairs. Pronotum fairly hairy, anterior margin slightly excised, posterior lobes narrow and elongated. Tibial spurs 3:2:2. Abdomen hairy. Head yellowish red. Mandible bases pale yellowish red. Tergites yellow and sternites paler. Measurements are given in tables 32-33.

Table 31: Body measurements of *Odontotermes* sp. nr. *monodon*, soldier caste, Kajiado nest colony

	HEAD		CAPSULE		MANDIBLES				ANTENNAL FOVEOLAR DISTANCE	PROMOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE				
n	16	16	16	16	16	16	16	16	16	16	16	16
Range	3.60-3.93	2.90-3.22	1.97-2.17	1.18-1.33	1.87-1.97	0.68-0.77	1.80-1.93	0.75-0.87	2.08-2.27	2.03-2.20	2.23-2.40	0.20-0.33
Mean	3.77	3.10	2.02	1.26	1.93	0.73	1.88	0.81	2.17	2.13	2.31	0.29
SD	0.10	0.20	0.23	0.04	0.03	0.02	0.03	0.03	0.05	0.05	0.05	0.03
CV	2.66	6.56	11.22	3.40	1.64	3.25	1.78	3.45	2.22	2.38	2.04	9.94



Table 32: Body measurements of *Odontotermes* sp. nr. monodon, major workers, Kajiado nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.87-2.47	1.80-2.00	0.40-0.60	0.87-1.20	1.33-1.80
Mean	2.10	1.94	0.48	1.07	1.62
SD	0.15	0.06	0.07	0.08	0.10
CV	7.24	3.25	14.63	7.34	6.25

Table 33: Body measurements of *Odontotermes* sp. nr. monodon, minor workers, Kajiado nest colony

n	20	20	20	20	20
Range	1.47-1.60	1.13-1.27	0.20-0.47	0.50-0.87	1.00-1.33
Mean	1.35	1.19	0.34	0.79	1.21
SD	0.12	0.04	0.08	0.09	0.10
CV	8.92	3.08	22.04	11.10	8.11

Imago. Winged male and female. Head sub-circular. Few long scattered hairs and numerous small and slender ones. Fontanelle region with two conspicuous light spots. Frons depressed and with median carina. Behind the clypeus rough and grooved, marked by two furrows. Clypeus convex and hairy. In males ante-clypeus triangular and creamy in appearance while in female ante-clypeus with arcuate margin and not creamy. Eyes circular. Ocelli oval. Antennae with 19-20 segments. When 19 segments, III almost equal to V and where 20 segments, III splits into two equal parts hence the shortest segments. All segments hairy. Labrum moderately hairy, tongue-shaped and with sclerotized band. Pronotum densely hairy, anterior margin irregular. Males with pronotum rounded. Female pronotum with posterior margins irregular. Wings more than twice the body length. Tibial spurs 3:3:2 with 3rd spur of mid-tibia reduced, slender and paler. Head dark red that of males darker. Eyes black to reddish grey. Antennae pale red brown. Mandible bases reddish yellow, other parts including teeth dark red. Wings reddish yellow; pronotum dark red. Legs yellow red. Measurements are given in table 34.

Affinities: Odontotermes sp.nr. monodon is a member of the rather homogeneous group of species which includes Odontotermes badius and Odontotermes sp.nr. badius. However, Odontotermes sp. nr. monodon has a longer head capsule than other species in the same group. Odontotermes sp. nr. monodon is most closely allied to Odontotermes monodon, but is quite distinct by virtue of its shallow depression on the frons.

Table 34: Body measurements of *Odontotermes* sp. nr. *monodon* alates, males (♂) and females (♀), Kajiado nest colony

	Head Width including eyes	Inter Ocellar distance	labrum max. width	Pronotum		Hind tibia	
				Max length	Max width	Max. length	Max. width
♂							
n	6	6	6	6	6	6	6
Mean	3.12	1.92	1.34	1.25	3.04	3.09	0.32
SD	0.11	0.03	0.02	0.12	0.12	0.25	0.03
CV	3.68	1.42	2.00	9.75	3.83	8.27	8.50
♀							
n	10	10	10	10	10	10	10
Mean	3.02	1.85	1.29	1.46	3.08	2.90	0.29
SD	0.11	0.06	0.08	0.19	0.07	0.30	0.03
CV	3.62	3.32	6.50	13.00	2.24	10.29	11.82

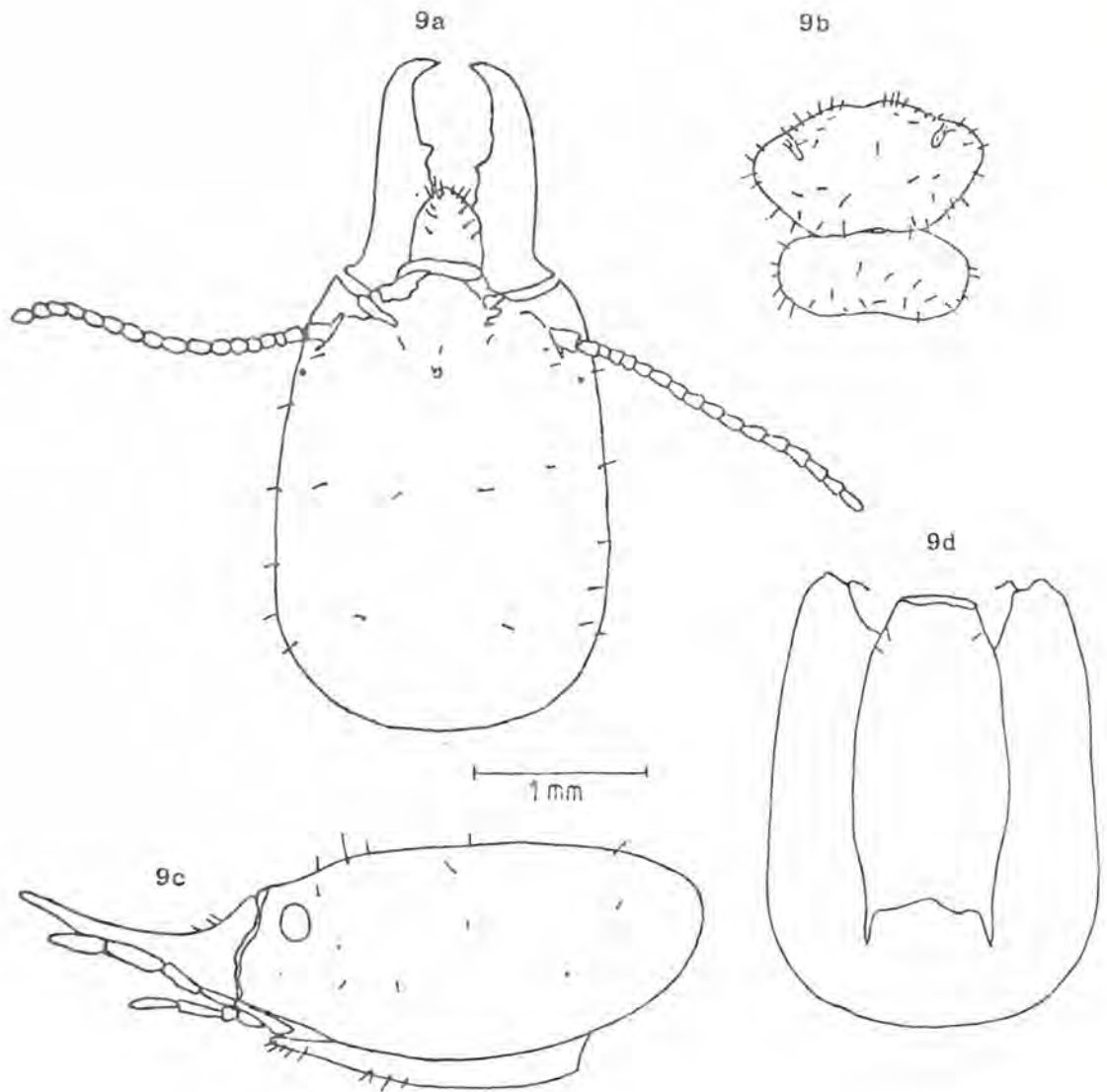
Odontotermes montanus Harris

Study area nest colonies. Muguga, Oleserewa  
Limuru, Kileleshwa. Soldier, worker and imago  
(Figs.9a - 9d)

DESCRIPTION. Soldier. Total body length range 7.0 to 8.7 mm (n=20). Head elongate rectangular with arcuate posterior margin and sides converging slightly towards the front. Frons with minute grooves. Antennae with 17 segments, III the shortest, IV slightly larger than V. Labrum rounded towards anterior portion and tip pointed, surface with numerous bristles. Gula widest at the middle (Fig. 9a), anterior margins straight and rounded. Mandibles robust with incurved tips. Left mandible with median tooth projecting at right angles (Fig. 9a). The edge distal to the tooth serrated. Right mandible with a median tooth at an obtuse angle to the inner edges of the mandible. Pronotum with large anterior lobes and distinct median notch. Posterior margin wide and broadly bilobed. Tibial spurs 3:3:2. Rest of body moderately hairy.

Head reddish brown. Antennal bases dark brown and segments pale brown. Mandibles brownish becoming brown near their bases. Legs and rest of the body light yellow. Measurements are given in table 35.





Figs. 9a - 9b. Morphology of Odontotermes montanus, Soldier caste:

9a - head capsule, dorsal view

9b - pronotum and mesonotum

9c - head, profile

9d - gula

Table 35: Body measurements of *Odontotermes montanus*, soldier caste, Muguga nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PROMOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	2.43-2.83	1.80-2.03	1.30-1.52	0.80-0.90	1.38-1.57	0.51-0.59	1.40-1.53	0.63-0.68	1.38-1.55	1.23-1.43	1.47-1.73	0.20-0.23
Mean	2.63	1.91	1.39	0.85	1.46	0.55	1.45	0.66	1.46	1.33	1.60	0.21
SD	0.12	0.08	0.06	0.03	0.05	0.02	0.05	0.02	0.06	0.07	0.08	0.01
CV	4.41	4.09	4.42	3.13	3.63	4.55	3.40	2.71	4.21	4.95	4.68	6.29

Worker. Major and minor. Head with posterior margin smoothly rounded. Fontanelle spot very conspicuous especially in major worker. Frons area depressed. Clypeus conspicuous, postclypeus convex, with sides transparent. Major worker with 17-18 antennal segments. Minor worker always with 17 antennal segments, when 17 segments III is the shortest and when 18 segments IV is the shortest. Labrum broad and hairy. Bases of mandibles with a few hairs. Pronotum upturned with anterior median notch, posterior lobes with smoothly rounded margins. Posterior margin excised. Tibial spur 3:3:2, with third spur of mid-tibia slender but noticeable. Rest of body fairly hairy. Head pale reddish yellow to pale yellow. Antennae pale proximally to dark brown distally. Base of mandible reddish yellow and becoming reddish towards the teeth region, teeth dark red. Rest of body light yellow. Measurements are given in tables 36-37.

Reproductives. King and Queen. Head sub-oval moderately hairy with both long and short hairs. Fontanelle region conspicuous with light spots. Area between frons and epistome depressed with small markings. Ocelli large and oval. Eyes protruding. Labrum and mandibles similar to those of the workers. Pronotum sub-circular, anterior margin upturned. Posterior margin straight. Rest of body hairy; King with pair of short sclerotised setae on last sternite. Head reddish with dark reddish yellow hairs. Pronotum red; rest of body reddish brown.

Table 36: Body measurements of Odontotermes montanus, major workers, Muguga nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	2.00-2.33	1.67-1.73	0.10-0.40	0.80-1.00	1.00-1.33
Mean	2.17	1.70	0.31	0.94	1.28
SD	0.09	0.03	0.06	0.07	0.08
CV	4.17	2.01	20.51	6.98	6.33

Table 37: Body Measurements of Odontotermes montanus minor workers, Muguga nest colony

n	20	20	20	20	20
Range	1.20-1.60	1.07-1.20	0.33-0.40	0.73-0.87	1.00-1.20
Mean	1.45	1.17	0.36	0.79	1.07
SD	0.09	0.04	0.03	0.03	0.05
CV	6.36	3.42	9.23	3.74	4.91



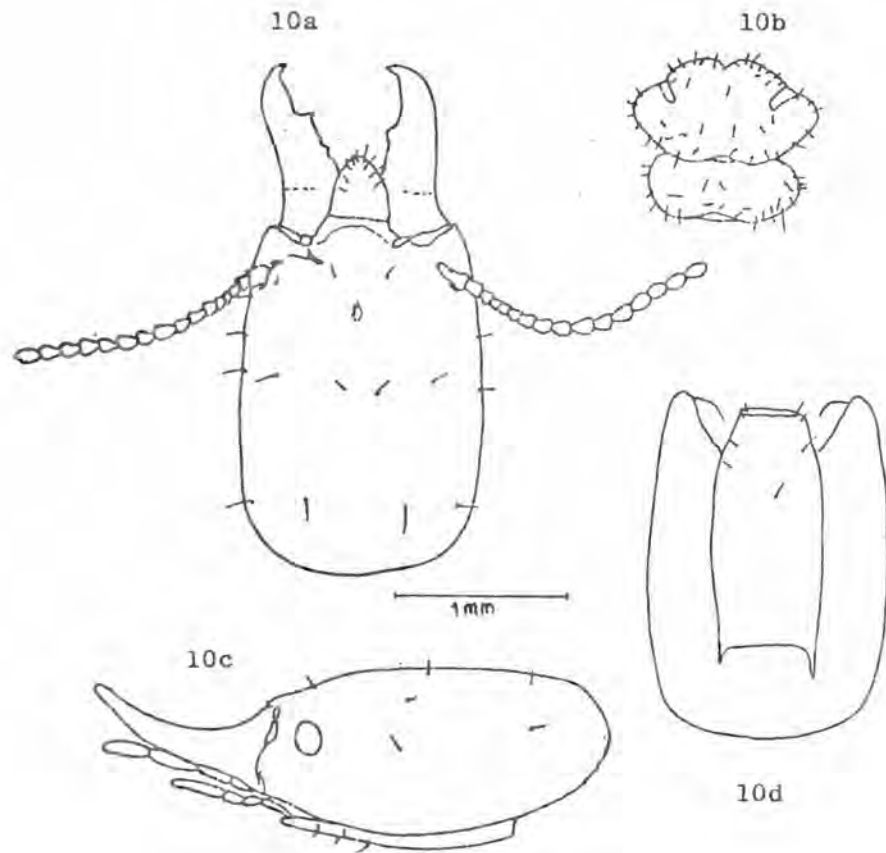
Affinities: Odontotermes montanus is closely allied to Odontotermes tanganicus and Odontotermes patruus on the basis of general shape and in particular the morphology of the head. Sjöstedt (1915) ascribed a single specimen of Odontotermes montanus from Naivasha, Kenya, to Odontotermes tanganicus but the unique feature of Odontotermes montanus is that it is larger, with the sides of the head flatter, the mandibles proportionally larger and more slender and the median tooth on the right mandible more conical.

Odontotermes nolaensis Sjostedt

Study area nest colonies: - Langata,  
Ruaraka, Ngong. Soldier, worker & imago  
(Fig. 10a - 10d)

DESCRIPTION. Soldier. Total body length range from 5.4 to 6.9 mm (n=35). Head elongate rectangular with parallel sides, posterior corners smoothly rounded. Head tapering anteriorly. Hairs very few. Frons smooth and slightly flattened towards the clypeus. Antennae with 16 segments, IV the shortest, III slightly shorter than V, VI a little longer than V, fairly globular, those succeeding rather longer. Gula ribbon-like and narrowing posteriorly, anterior portion with few hairs,. Labrum narrowed anteriorly, sides parallel, bristles few and long.

Mandibles fairly robust with incurved tips. The teeth of both mandibles distinct and fairly equal in width. Left mandible with median tooth very pointed and with its upper edge at right angles to the mandibular axis. Below mandibular tooth on the inner edges with denticles and above usually undulant. Right mandibular tooth smaller and sharp, slightly at an obtuse angle to mandibular axis, above usually serrated. Thorax with moderate hair. Pronotum with anterior margin nearly excised. Femur less hairy than tibia. Tibial spurs 3:3:2, third spur of mid-tibia very reduced.



Figs. 10a- 10d. Morphology of Odontotermes nolaensis soldier caste:

10a - head capsule, dorsal view,

10b - pronotum and mesonotum,

10c - head, profile,

10d - gula.

Abdomenal segments with dense hairs and elongated. Head colour variable from red to reddish yellow. Antennal segments pale brown. Gula pale reddish yellow. Mandibles dark red with reddish orange bases. Thorax and rest of body and pale yellow. Measurements are given in tables 38-39.

Workers. Major and minor. Head of major worker U-shaped, lateral margins constricted. Head of minor worker sub-oval with unconstricted margins. Head moderately hairy. Fontanelle knob conspicuously white and on a shallow depression. Behind clypeal suture forehead depressed. Post-clypeus convex and ante-clypeus triangular. Eye spots present. Minor worker with 16-17 antennal segments. Major worker with 17 antennal segments. Where antennal segments are 16, IV is the shortest and when 17, II is the shortest. Labrum broad and with bristles. Mandible bases with scattered hairs. Pronotum with upright anterior lobes, posterior margin excised and corners rounded.

Head pale yellow to yellow orange; mandible bases yellowish to pale red, teeth and anterior regions of mandibles reddish. Rest of body pale yellowish. Measurements are given in table 40 - 43



Table 38: Body measurements of *Odontotermes nolaensis*, soldier caste, Langata nest colony

	HEAD CAPSULE			MANDIBLES				ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH	
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH					RIGHT TOOTH DISTANCE
n	16	16	16	16	16	16	16	16	16	16	16	
Range	2.08-2.30	1.33-1.50	1.03-1.13	0.61-0.72	1.10-1.20	0.40-0.47	1.10-1.23	0.47-0.53	1.13-1.25	1.07-1.20	1.17-1.27	0.17-0.20
Mean	2.20	1.42	1.07	0.67	1.16	0.44	1.14	0.49	1.17	1.11	1.22	0.18
SD	0.06	0.05	0.03	0.03	0.04	0.02	0.04	0.02	0.04	0.04	0.03	0.02
CV	2.61	3.34	2.55	4.05	3.69	0.02	3.49	4.70	3.15	4.02	2.61	9.01

Table 39: Body measurements of *Odontotermes nolaensis*, soldier caste, Ruaraka nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	2.07-2.17	1.33-1.43	1.02-1.10	0.62-0.68	1.08-1.14	0.40-0.43	1.08-1.13	0.45-0.48	1.08-1.15	1.00-1.11	1.07-1.17	0.17-0.18
Mean	2.10	1.38	1.05	0.65	1.12	0.42	1.10	0.46	1.11	1.05	1.12	0.17
SD	0.03	0.03	0.02	0.02	0.02	0.01	0.02	0.01	0.03	0.03	0.03	0.00
CV	1.36	0.03	2.38	3.30	1.55	2.81	1.57	2.52	2.46	2.56	2.56	2.63

Table 40: Body measurements of Odontotermes nolaensis, major workers, Langata nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.73-2.00	1.47-1.60	0.27-0.40	0.67-0.93	1.00-1.33
Mean	1.90	1.54	0.34	0.80	1.03
SD	0.09	0.06	0.04	0.06	0.08
CV	4.63	3.77	11.96	6.92	7.42

Table 41: Body measurements of Odontotermes nolaensis, minor workers, Langata nest colony

n	20	20	20	20	20
Range	1.13-1.33	0.67-1.07	0.33-0.47	0.67-0.73	0.73-1.00
Mean	1.29	0.99	0.37	0.69	0.86
SD	0.06	0.08	0.04	0.03	0.09
CV	4.49	8.12	10.63	4.59	11.09

Table 42: Body measurements of Odontotermes nolaensis, major workers, Ruaraka nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.33-1.93	1.33-1.60	1.00-0.40	0.33-0.87	0.73-1.20
Mean	1.70	1.49	0.32	0.72	0.99
SD	0.18	0.07	0.05	0.12	0.90
CV	10.41	4.61	14.54	16.06	9.08

Table 43: Body measurements of Odontotermes nolaensis, minor workers, Ruaraka nest colony

n	20	20	20	20	20
Range	0.87-1.27	1.00-1.07	0.27-0.40	0.60-0.67	0.60-0.87
Mean	1.07	1.01	0.34	0.66	0.77
SD	0.12	0.02	0.03	0.02	0.08
CV	11.21	2.05	10.08	3.13	9.93



Imago. Winged males and females. Head sub-oval, densely covered with fine hairs. Fontanelle spot present and enclosed by light coloured markings; carina present. Epistome arched with a dark line. Ante-clypeus rectangular. Ocelli sub-circular. Eyes large and rounded. Antennae with 19 segments, III the smallest, IV and V almost equal. Mandibles hairy at their bases. Pronotum saddle-shaped with dense hair, broadly rounded concave anterior corners, hair dense. Lateral margins irregular converging towards posterior. Posterior margin cut off, depressed, and with striations. Wings twice the length of the body. Forewing with cubitus branched into 11 to 16 veins. Head dark brown, anteclypeus lighter than post-clypeus. Antennal segments brownish red. Mandibles reddish at their bases, wings brown tinged. Rest of body pale brownish red. Measurements are given in table 44.

Affinities: Odontotermes nolaensis is most closely allied to Odontotermes stercorivorus and is only separated by body size differences.

Table 44: Body measurements of *Odontotermes nolaensis*, alates, males (♂) and females (♀), Langata nest colony

	Head width including eyes	Inter-ocellar distance	labrum max. width	Pronotum		Hind tibia	
				Max. length	Max. width	Max. length	Max. width
♂							
n	10	10	10	10	10	10	10
Mean	2.71	1.61	1.22	1.16	2.55	2.67	0.28
SD	0.45	0.04	0.08	0.15	0.23	0.20	0.03
CV	1.72	2.35	6.84	13.35	9.20	7.45	11.31
♀							
n	10	10	10	10	10	10	10
Mean	2.65	1.62	1.20	1.21	2.62	2.48	0.27
SD	0.03	0.15	0.06	0.07	0.07	0.22	0.04
CV	1.06	9.10	5.32	5.67	2.70	8.76	13.95

Odontotermes patruus Sjostedt

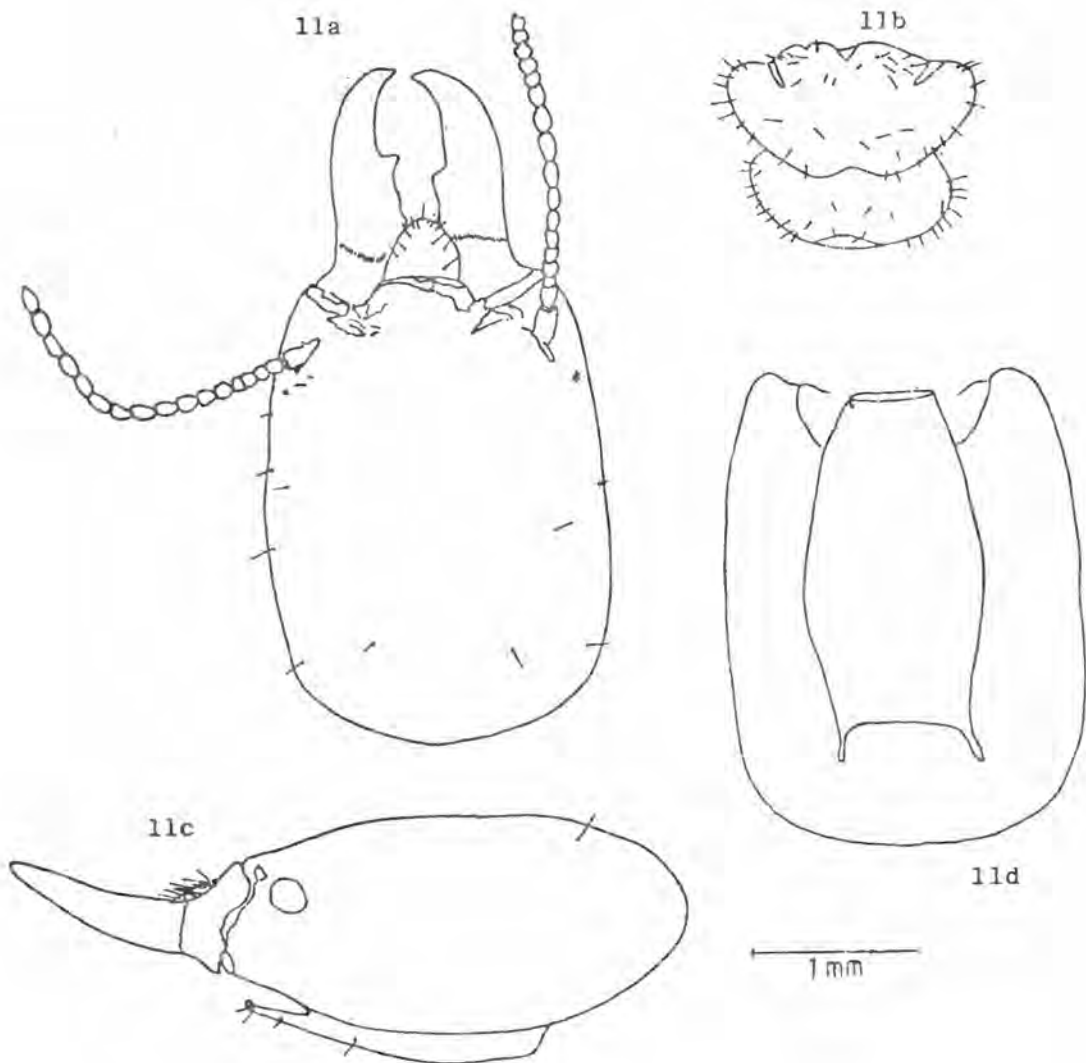
Study area nesty colony: - Muguga-Limuru.

Soldier and worker

(Figs. 11a - 11d)

DESCRIPTION. Soldier. Total body length range 9.0 to 10.0 mm (n=13). Head rectangular with posterior corners rounded off, anterior end faintly tapering. Hairs scarce. Frons nearly flattened with faint transverse wave, with carina scarcely visible from dorsal view, runs from the inner mandible base towards small depressions on each side. Clypeal region flat. Antennae with 17 segments, III the smallest followed by V. Basal segment not as long as the next three together. The middle segments barrel-shaped, terminal segment oval, somewhat tapered. Gula long and narrowing posteriorly, widest across the middle. Lateral margins undulating towards front (Fig. 10d). Anterior portion with a few long hairs. Labrum short and broad with long bristles.

Mandibles narrowing towards the front with sharply incurved tips. Left mandibles with inner margins below the median tooth uneven, upper edges of the median tooth at right angles to the bases of inner margins of mandibles. Right mandible tooth slightly smaller and nearly at an obtuse angle to the bases of inner margins; below tooth on inner edges



Figs. 11a - 11d. Morphology of Odontotermes patruus, soldier caste:

11a - head capsule, dorsal view,

11b - pronotum and mesonotum,

11c - head, profile,

11d - gula.



mandible is minutely crenate. Mandible bases smooth. Pronotum with moderately scarce hairs, anterior lobes deeply incised, posterior lobes sub-circular. Legs hairy, tibial spurs 3:3:2 with third spur of mid-tibia very small. Abdomen fairly hairy.

Head yellowish-red to brownish red. Gula red brown. Mandibles black with red bases. Thorax pale yellow to yellowish brown. Tibia lighter than femur. Abdomen with brownish segments. Measurements are given in table 45

Worker. Major and minor. Head with smoothly rounded posterior, that of minor worker exceptionally wide anteriorly while that of major worker is constricted on the sides. Hairs moderate. Frons flat and depressed with a white fontanelle spot. Postclypeus raised convex with depressed anteriorly portion, median line conspicuous. Ante-clypeus triangular with transparent edges. Antennae with 17-18 segments and with hairs. When 17 segments, III is the smallest followed by V, when 18, IV is the shortest. Labrum broad and depressed at the middle, and with few bristles. Thorax hairy. Pronotum with upright anterior lobes and a median notch. Posterior lobe margin excised, sides straight with rounded corners. Tibial spurs 3:3:2, third spur on mid-tibia reduced. Abdomen hairy. Head pale yellow to yellowish-brown. Eye spots brown and conspicuous. Antennal segments pale brown basally to dark

Table 45: Body measurements of Odontotermes patruus, soldier caste, Deiya-Limuru nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	13	13	13	13	13	13	13	13	13	13	13	13
Range	2.60-3.07	1.96-2.33	1.37-1.70	0.93-1.13	1.50-1.69	0.58-0.65	1.47-1.67	0.65-0.73	1.48-1.80	1.43-1.70	1.67-1.92	0.20-0.25
Mean	2.89	2.19	1.55	1.03	1.59	0.61	1.56	0.69	1.65	1.57	1.81	0.23
SD	0.14	0.12	0.10	0.05	0.06	0.02	0.06	0.03	0.09	0.09	0.08	0.01
CV	4.84	5.63	6.21	5.36	3.60	3.73	3.67	3.86	5.78	5.89	4.24	6.00

brown distally. Mandibles pale red, yellow at bases to reddish teeth. Thorax yellowish and tibia paler than femur. Abdomen pale yellow. Measurements are given in tables 46-47.

Affinities. Odontotermes patruus is closely related to Odontotermes amaniensis but it is characterised by its rectangularly shaped head capsule. Odontotermes patruus is also close to Odontotermes montanus but it is larger (see page 119).

**Table 46: Body measurements of *Odontotermes patruus*, major workers, Deiya-Limuru nest colony**

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.80-2.73	1.53-1.67	0.27-0.40	0.73-1.00	1.06-1.40
Mean	2.07	1.63	0.33	0.93	1.28
SD	0.18	0.05	0.03	0.09	0.09
CV	8.77	3.09	10.31	9.30	7.05

**Table 47: Body measurements of *Odontotermes patruus*, minor workers, Deiya-Limuru nest colony**

n	20	20	20	20	20
Range	1.20-1.40	1.00-1.20	0.33-0.53	0.73-1.06	1.00-1.07
Mean	1.33	1.11	0.39	0.78	1.02
SD	0.04	0.04	0.08	0.07	0.03
CV	3.24	4.04	19.76	9.50	2.93



Odontotermes stercorivorus (Sjostedt)

Study area nest colonies:- Chiromo, Kileleshwa, Langata,  
Ngong, Ruaraka. Soldier, worker and imago  
(Figs. 12a - 12d)

DESCRIPTION: Soldier. Total body length range 4.7 to 7.1 mm (n=50). Head elongate rectangular with lightly curved posterior margin. Posterior corners smoothly rounded. Sides straight and tapering anteriorly. Hairs few. Frons smooth and raised, sloping downwards to clypeal region. Eye spots present. Clypeus very small or absent. Antennae with 16 segments, IV the smallest, II about as long as the two succeeding ones together, the segments gradually narrowing in size distally, fairly globular, the terminal segment rather larger than the preceding pear shaped, slightly contracted distally. Gula long and rectangular, slightly constricted anteriorly, anterior edge straight. Posterior part narrow, hairs concentrated on the anterior region. Labrum with a few bristles.

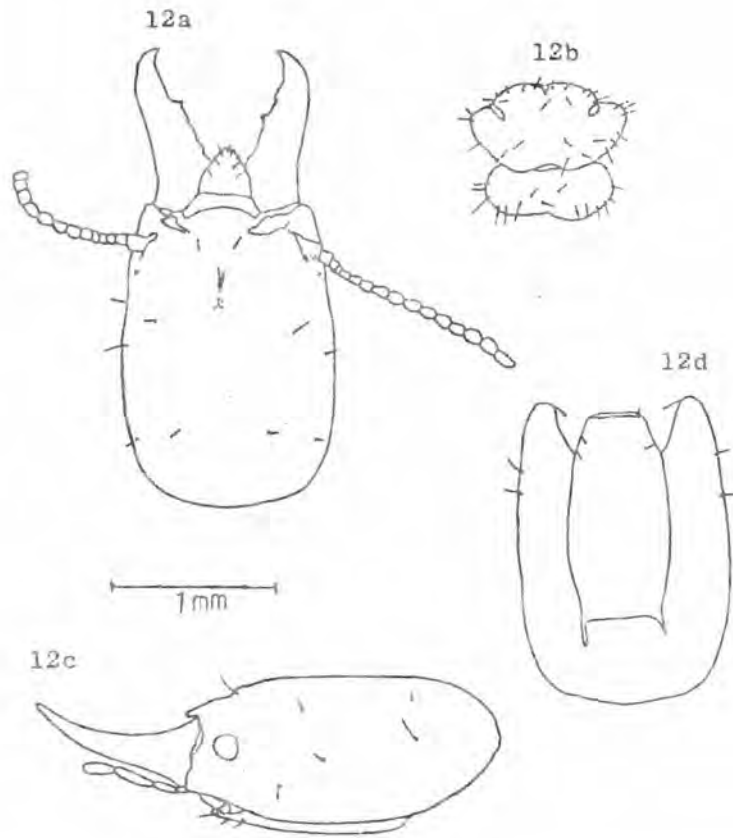


Fig. 12a - 12d. Morphology of Odontotermes stercorivorus,  
 Soldier caste:  
 12a - head capsule, dorsal view,  
 12b - pronotum and mesonotum,  
 12c - head, profile,  
 12d - gula,

Mandibles fairly straight with incurved points. Both with conspicuous median tooth. Left tooth larger with its upper edge at right angles to the inner edge of the mandible, sinuate above the tooth on inner margins and with minute undifferentiated teeth below. Right median tooth cone-shaped and at right angles to the inner edges of mandibles, inner edges sinuated. Thorax moderately hairy. Pronotum with deeply notched anterior margin and posterior deeply excised. Metanotum almost rectangular. Legs hairy. Tibial spurs 3:2:2. Abdomenal segments thickly pilose. Abdomen elongate. Head yellowish red to reddish yellow. Mandibles dark red to red at bases. Thorax pale yellow, tibia paler than femur and coxa. Abdomen pale yellow. Measurements are given in tables 48-50.

Worker. Major and minor. Head ovate to sub-circular, that of major worker constricted laterally, posterior rounded. Hairs moderate and short. Frons smooth with a white spot. Clypeus raised, postclypeus with a median line; area between clypeus and frons raised. Antennae with 16-17 segments. Major worker with only 17 segments, III very small, V slightly smaller than IV, II as long as III and IV together. Minor worker with 16 segments, IV the shortest. Major worker with 17 segments. Pronotum smaller anterior lobes with and more uprightly held than posterior with lobes. Posterior lobes with margins fairly straight and deeply notched at the middle. Tibial spurs 3:2:2. Rest of body fairly hairy.

Table 48: Body measurements of Odontotermes stercorivorus, soldier caste, Kileleshwa nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	1.90-2.03	1.23-1.33	0.93-1.00	0.60-0.67	1.03-1.10	0.40-0.43	1.02-1.10	0.43-0.47	1.03-1.12	0.93-1.03	1.07-1.17	0.13-0.17
Mean	1.95	1.28	0.97	0.62	1.07	0.41	1.06	0.45	1.06	0.98	1.12	0.15
SD	0.05	0.03	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.03	0.03	0.01
CV	2.45	2.31	1.71	3.42	1.87	2.71	2.29	2.26	2.20	3.21	2.46	7.82



Table 49: Body measurements of *Odontotermes stercorivorus*, Soldier caste, Langata nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	1.97-2.17	1.30-1.45	1.00-1.10	0.60-0.68	1.07-1.15	0.38-0.45	1.07-1.17	0.43-0.50	1.07-1.19	0.98-1.11	1.10-1.22	0.15-0.20
Mean	2.06	1.38	1.05	0.65	1.12	0.41	1.11	0.47	1.12	1.05	1.15	0.17
SD	0.06	0.04	0.03	0.03	0.02	0.02	0.03	0.02	0.04	0.04	0.03	0.01
CV	3.12	3.16	2.64	3.63	2.38	4.46	3.10	4.32	3.31	3.54	2.63	8.02

Table 50: Body measurements of Odontotermes stercorivorus soldier caste, Ruaraka nest colony

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA WIDTH
n	16	16	16	16	16	16	16	16	16	16	16	16
Range	1.90-2.15	1.27-1.40	1.00-1.03	0.57-0.67	1.07-1.13	0.42-0.45	1.05-1.10	0.43-0.48	1.03-1.12	0.93-1.02	1.10-1.17	0.13-0.17
Mean	2.02	1.34	1.01	0.62	1.09	0.41	1.08	0.46	1.08	0.99	1.14	0.16
SD	0.07	0.04	0.02	0.03	0.02	0.07	0.02	0.01	0.03	0.03	0.02	0.01
CV	3.37	2.76	1.58	4.48	1.86	16.06	1.54	2.40	2.40	2.70	1.67	5.92

Head pale reddish yellowish. Antennal segments pale brown. Thorax pale yellowish. Rest of body pale.

Measurements are given in tables 51-56.

Imago. Winged males and females. Head oval, posterior margin rounded from eye position, anterior lateral margins irregular and narrowed. Hairs dense. Frons area raised with carina and fontanelle. Postclypeus rectangular with a median line, ant-clypeus triangular. Ocelli and eyes sub-circular. Labrum densely hairy. Bases and surface of mandibles hairy. Pronotum densely hairy, posterior margins compressed at the middle and striated.

Head dark reddish brown, ante-clypeus higher than postclypeus. Eyes black. Labrum reddish yellow, mandibular margins and teeth dark reddish. Measurements are given in table 57.

Affinities: Odontotermes stercorivorus is most closely allied to Odontotermes nolaensis (see page 125). Principal characters in common are the general shape (rather rectangular head shape in soldiers, similar numbers of antennal segments, frons slanting forward and mandibular characteristics). However difference is in size e.g. in soldiers the length of the body from anterior end of pronotum to the end of last abdominal segment of O. stercorivorus is larger than that O. nolaensis.

Table 51: Body measurements of Odontotermes stercorivorus, major workers, Kileleshwa nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.60-1.87	1.33-1.47	0.27-0.40	0.67-0.80	0.80-2.00
Mean	1.74	1.41	0.33	0.73	1.02
SD	0.06	0.04	0.03	0.06	0.08
CV	3.62	2.78	7.97	8.33	7.69

Table 52: Body measurements of Odontotermes stercorivorus, minor workers, Kileleshwa colony

n	20	20	20	20	20
Range	1.00-1.33	0.93-1.00	0.33-0.40	0.60-0.67	0.73-1.00
Mean	1.10	0.99	0.34	0.65	0.87
SD	0.24	0.01	0.02	0.03	0.09
CV	21.76	1.48	5.98	4.88	10.31



Table 53: Body measurements of Odontotermes stercorivorus, major workers, Langata nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	15	15	15	15	15
Range	1.67-1.93	1.47-1.60	0.20-0.40	0.60-0.80	0.73-1.07
Mean	1.83	1.51	0.29	0.71	0.99
SD	0.10	0.06	0.05	0.05	0.08
CV	5.49	3.88	18.93	7.67	7.98

Table 54: Body measurements of Odontotermes stercorivorus, minor workers, Langata nest colony

n	20	20	20	20	20
Range	1.00-1.33	0.80-1.07	0.27-0.40	0.47-0.67	0.73-1.00
Mean	1.20	0.99	0.33	0.64	0.82
SD	0.11	0.07	0.03	0.06	0.11
CV	9.32	7.20	10.31	9.29	13.47

Table 55: Body measurements of Odontotermes stercorivorus, major workers, Ruaraka nest colony

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	1.33-2.60	1.33-1.47	0.20-0.33	0.60-0.80	0.93-1.00
Mean	1.70	1.42	0.31	0.70	0.98
SD	0.35	0.04	0.05	0.07	0.03
CV	20.54	3.01	14.90	9.44	3.31

Table 56: Body measurements of Odontotermes stercorivorus, minor worker, Ruaraka nest colony

n	20	20	20	20	20
Range	0.93-1.33	0.93-1.00	0.27-0.40	0.47-0.67	0.67-1.00
Mean	1.10	0.99	0.34	0.63	0.82
SD	0.10	0.01	0.03	0.06	0.09
CV	9.13	1.48	7.78	10.02	10.89

Table 57: Body measurements of *Odonotermes stercorivorus*, alates, males (♂) and females (♀), Langate nest colony

	Head width including eyes	Inter-ocellar distance	labrum max. width	Pronotum		Hind tibia	
				Max. length	Max. width	Max. length	Max. width
♂							
n	10	10	10	10	10	10	10
Mean	2.68	1.61	1.26	1.21	2.36	2.59	0.27
SD	0.07	0.06	0.08	0.17	0.29	0.15	0.05
CV	2.63	4.27	6.34	14.59	12.65	5.99	18.96
♀							
n	10	10	10	10	10	10	10
Mean	2.63	1.58	1.20	1.24	2.54	2.47	0.27
SD	0.03	0.06	0.10	0.14	0.09	0.22	0.04
CV	1.45	3.86	8.70	11.62	3.49	8.97	13.98

Odontotermes sp. nr. tanganicus

Study area nest colonies: - Kajiado.

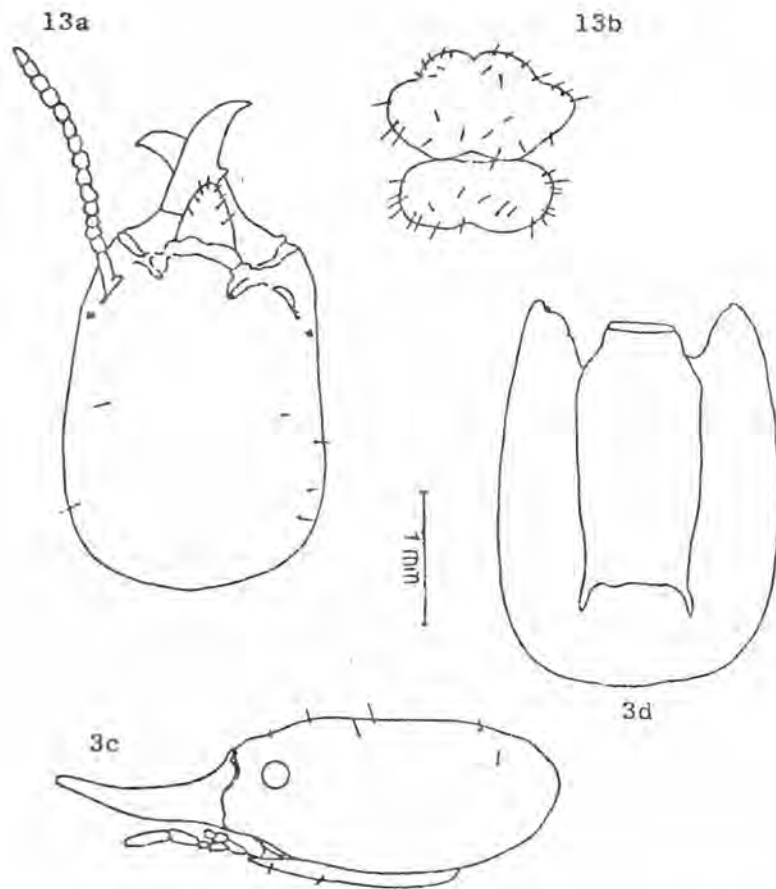
Soldier, worker and imago

(Figs.13a - 13d)

DESCRIPTION. Soldier. Total body length range 5.6 to 7.7 mm (n=30). Head elongate, nearly rectangular, smoothly rounded and narrowed margins. Lateral margins converging towards the front. Hair scarce and scattered mainly on the forehead. Frons smooth and slanting downwards to clypeal region. Clypeus usually rectangular with anterior margins raised. Eye spot faint. Antennae with 16 - 17 segments. When 16 segments, IV is the shortest followed by IV. Gula strongly rectangular with lateral margins converging to front, a few setae at the anterior region. Labrum pointed and longer than broad with long anterior bristles.

Both mandibles with incurved tips and prominent median tooth. Bases smooth. Upper edges of the left tooth approximately at right angles to the inner axis of the mandibles (Fig.13a). Above the tooth is a wide gap, followed by sinuated margins. Below median tooth are minute teeth usually undifferentiated. Right mandible tooth blade like, smaller than left and almost at right angles to the mandibular axis. Thorax with scarce hairs. Pronotum with anterior lobes smaller than posterior lobes. Posterior margin excised.





Figs. 13a - 13d. Morphology of Odontotermes sp. nr. tanganicus  
 Soldier caste:  
 13a - head capsule, dorsal view,  
 13b - pronotum and mesonotum,  
 13c - head, profile,  
 13d - gula.

Tibial spurs 3:3:2 with third spur on the mid-tibia reduced.  
Abdomen moderately hairy.

Head capsule reddish yellow to orange yellow. Antennal segments pale yellow. Gula pale reddish yellow. Mandibles reddish yellow at bases. Measurements are given in tables 58 - 59.

Worker. Major and minor. Head shape similar to Odontotermes nolaensis discussed on page 127. Hairs moderately scarce. Fontanelle spot in a depression, area between frons and clypeal suture deeply depressed. Post clypeal raised and convex, ante-clypeus long and pointed with middle portion raised. Eye spot present. Antennae with 17 segments, III shortest, V slightly larger than III. Labrum broad with long bristles. Bases of mandible smooth. Pronotum with anterior lobes held upward. Posterior lobes with lateral margins straight. Posterior margin excised. Tibial spur 3:3:2. Rest of body hairy. Head pale reddish yellow to brownish yellow. Antennae pale yellow proximally to brownish yellow distally. Mandible yellowish to dark red. Measurements are given in tables 60 - 61.

Reproductives. King and Queen. Head densely pilose. Fontanelle spot conspicuous and in a raised ridge. King with two large markings between clypeal suture and ocelli. Queen without markings. Postclypeus slightly concave. Ocelli ovate, eyes sub-circular. Antennal segments hairy, segment III

Table 58: Body measurements of *Odontotermes* sp.nr. *tanganicus*, soldier caste, Kajiado nest colony one

	HEAD CAPSULE			MANDIBLES				ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH	
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH					RIGHT TOOTH DISTANCE
n	10	10	10	10	10	10	10	10	10	10	10	
Range	2.03-2.40	1.53-1.77	1.10-1.12	0.70-0.78	1.17-1.27	0.47-0.65	1.17-1.25	0.50-0.68	1.17-1.37	1.03-1.23	1.10-1.37	0.17-0.23
Mean	2.22	1.64	1.07	0.74	1.21	0.51	1.19	0.55	1.26	1.15	1.28	0.18
SD	0.11	0.07	0.04	0.02	0.03	0.05	0.03	0.05	0.07	0.06	0.07	0.02
CV	4.93	4.47	3.70	3.39	2.75	10.49	2.57	9.11	5.61	5.51	5.82	8.49

Table 59: Body measurements of Odontotermes sp.nr. tanganicus, soldier caste, Kajiado nest colony two

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PROMOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	1.98-2.57	1.43-1.82	0.95-1.15	0.67-0.78	1.13-1.28	0.47-0.54	1.11-1.26	0.50-0.57	1.08-1.39	0.93-1.23	1.17-1.38	0.15-0.22
Mean	2.24	1.59	1.04	0.72	1.19	0.49	1.18	0.53	1.21	1.06	1.27	0.17
SD	0.17	0.12	0.06	0.04	0.05	0.02	0.05	0.02	0.09	0.09	0.07	0.02
CV	7.50	7.29	6.16	5.71	4.16	4.99	4.30	4.27	8.79	8.92	5.17	9.76



Table 60: Body measurements of *Odontotermes* sp.nr. tanganicus, major workers, Kajiado nest colony two

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	16	16	16	16	16
Range	1.63-1.67	1.33-1.43	0.33-0.33	0.67-0.80	1.00-1.00
Mean	1.68	1.38	0.33	0.76	1.00
SD	0.03	0.03	0.00	0.04	0.00
CV	2.05	2.47	0.00	5.41	0.00

Table 61: Body measurements of *Odontotermes* sp.nr. tanganicus, minor workers, Kajiado nest colony two

n	20	20	20	20	20
Range	1.00-1.33	0.93-1.00	0.27-0.40	0.60-0.73	0.67-0.93
Mean	1.13	0.99	0.33	0.67	0.79
SD	0.10	0.02	0.03	0.03	0.08
CV	9.09	1.48	9.15	3.94	9.60

shortest followed by V, VI and the succeeding segments globular. Labrum broad with bilobed tip. Mandibular bases hairy. Pronotum with anterior margin fairly straight and with a median notch. Pronotum with lateral margin slightly undulating, hairs dense. Legs densely hairy. Tibial spurs 3:2:2. Style and cerci pairs present. Head dark red to reddish yellow, postclypeus yellowish, ante clypeus pale yellow. Eyes black, mandible bases reddish. Middle portion of pronotum lighter in colour than the area surrounding the pronotum edges. Rest of body pale brownish yellow.

Affinities: Odontotermes sp. nr. tanganicus is a close ally of Odontotermes tanganicus from Tanga, which was referred to as Odontotermes transvaalensis by earlier workers until recognised by Sjostedt as a separate species in 1924.

Odontotermes transvaalensis has more rounded head than Odontotermes tanganicus which has slightly rectangular head. Odontotermes sp. nr. tanganicus differs from Odontotermes tanganicus in the morphology of the mandibles (see page 58).

Odontotermes sp. nr. zambesiensis

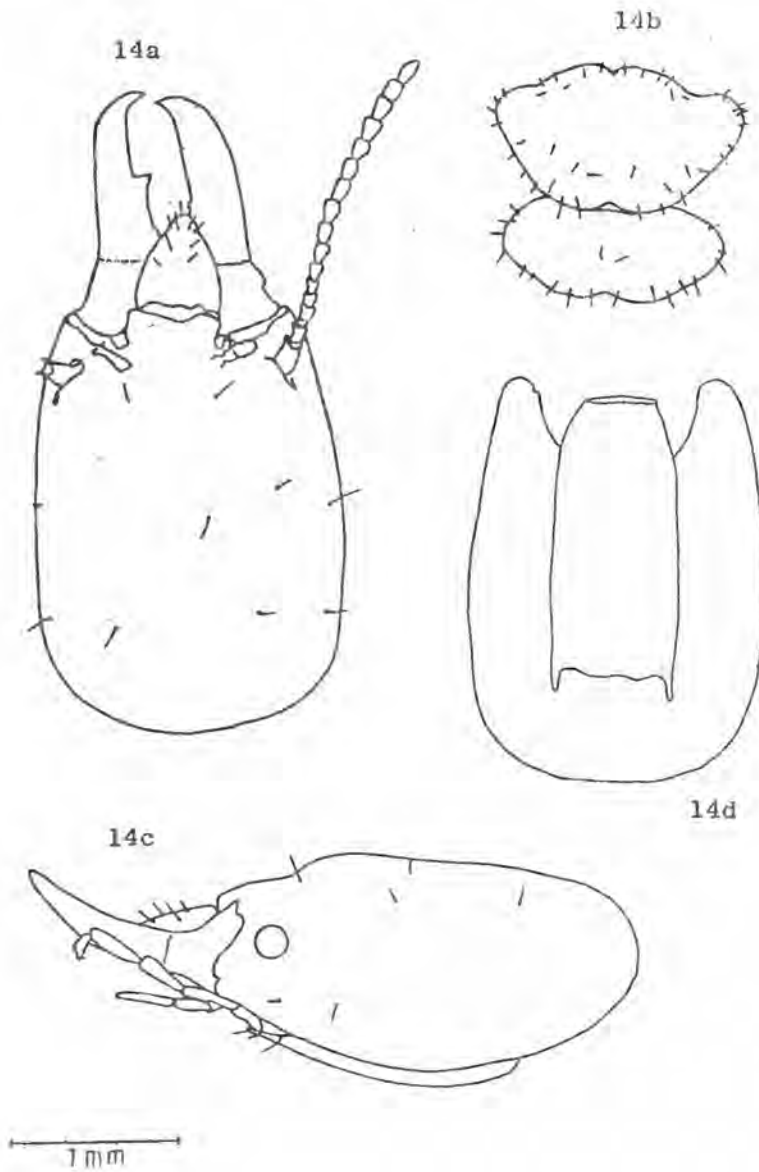
Study area nest colonies: - Kajiado.

Soldier, worker and imago

(Figs.14a - 14d)

DESCRIPTION. Soldier. Total body length range 6.9 to 8.7 mm (n=35). Head elongate and narrow. Posterior margin smoothly rounded. Lateral margins converging towards front. Hairs scarce. Frons region raised and with fontanelle spot. Frons slopes towards the clypeal region. Clypeus varies in size and is usually rectangular. Antennae with 17 segments, III shortest, IV exceptionally large and almost equal to VI. Lateral margins of gula undulant and posterior side broad, middle and anterior portions with hairs. Labrum narrow and pointed with long bristles.

Mandibles slender, sides straight and tips incurved. Mandibular bases smooth with scattered minute hairs. Left mandible with an arcuate median tooth whose upper edges are at an acute angle to the mandibular axis. Both upper and lower inner margins of mandible from the median tooth fairly smooth. Right mandible with small distinct cone-shaped median tooth, above and below blade-like. Pronotum with sparsely distributed hairs, anterior lobes with a median notch and margins fairly straight. Posterior lobes with straight lateral margins, posterior margin with curved edges and notched. Legs hairy, tibial spurs 3:3:2 third spur of mid-tibia reduced. Abdomen with dense hairs.



Figs. 14a - 14d. Morphology of *Odontotermes* sp. nr. *zambesiensis*, soldier caste:

14a - head capsule, dorsal view,

14b - pronotum and mesonotum,

14c - head, profile,

14d - gula.



Head pale reddish yellow, eye spot whitish. Antennal segments brownish. Gula reddish yellow. Mandibles dark red to pale red at bases. Labrum yellowish with whitish tips. Pronotum pale yellow. Rest of body yellowish. Measurements are given in tables 62 - 63.

Worker. Major and minor. Major worker with U-shaped head, but widening posteriorly and constricted laterally. Minor worker with sub-oval head. Hairs scarce. Fontanelle present on a depression. Major worker with post clypeus convex, that of minor worker more curved outwards, ante-clypeus long and pointed. Eye spot faint. Antennae with 18 - 19 segments in major worker and 17 segments in minor worker. When 17 or 19 segments III is shortest and when 18 segments occur, IV is the shortest and V almost equal to III. Labrum broad and spatulate with long bristles.

Pronotum with anterior lobes held upright and anterior margin with a small median notch. Posterior lobe narrowed towards the anterior corners. Posterior margins excised. Hair scarce. Legs moderately hairy. Tibia with rows of spines arranged on the inner margins, those of foretibia being stronger than either mid-or hind-tibia. Tibial spurs 3:3:2. Rest of body moderately hairy. Head pale reddish-yellow. Antennae pale basally and brown distally. Mandibles pale reddish yellow on the bases to reddish black on the teeth. Rest of body pale reddish yellow. Measurements are given in tables 64 - 65.

Table 62: Body measurements of *Odontotermes* sp.nr. *zambesiensis*, soldier caste, Kajiado nest colony one

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PRONOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH
n	15	15	15	15	15	15	15	15	15	15	15	15
Range	2.47-2.67	1.68-1.85	1.33-1.43	0.73-0.83	1.52-1.60	0.58-0.63	1.48-1.57	0.67-0.73	1.35-1.45	1.40-1.57	1.53-1.67	0.23-0.27
Mean	2.55	1.76	1.36	0.78	1.56	0.61	1.52	0.70	1.39	1.47	1.61	0.25
SD	0.07	0.04	0.04	0.04	0.03	0.01	0.02	0.02	0.03	0.04	0.04	0.01
CV	2.64	2.46	2.77	3.70	1.68	2.55	1.56	2.46	2.06	2.92	2.46	4.92

Table 63: Body measurements of *Odontotermes* sp.nr. *zambesiensis*, soldier caste, Kajiado nest colony two

	HEAD CAPSULE			MANDIBLES								
	LENGTH	WIDTH	DEPTH	GULA WIDTH	LEFT LENGTH	LEFT TOOTH DISTANCE	RIGHT LENGTH	RIGHT TOOTH DISTANCE	ANTENNAL FOVEOLAR DISTANCE	PROMOTUM WIDTH	HIND TIBIA LENGTH	HIND TIBIA LENGTH
n	18	18	18	18	18	18	18	18	18	18	18	18
Range	2.47-2.75	1.73-1.93	1.33-1.47	0.77-0.87	1.55-1.68	0.60-0.65	1.52-1.64	0.67-0.74	1.38-1.50	1.48-1.67	1.60-1.80	0.24-0.33
Mean	2.59	1.83	1.39	0.81	1.60	0.62	1.56	0.70	1.42	1.54	1.68	0.27
SD	0.08	0.06	0.03	0.03	0.04	0.02	0.03	0.02	0.04	0.06	0.05	0.03
CV	3.04	3.04	2.56	4.07	2.32	2.92	2.07	3.59	2.74	3.77	3.15	9.96

Table 64: Body measurements of *Odontotermes* sp.nr. zambesiensis major workers, Kajiado nest colony one

	HEAD CAPSULE		PRONOTUM		HIND TIBIA
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH
n	20	20	20	20	20
Range	2.40-2.67	1.73-1.93	0.33-0.53	1.00-1.13	1.33-1.47
Mean	2.50	1.84	0.44	1.07	1.40
SD	0.07	0.06	0.04	0.05	0.05
CV	2.94	3.23	9.30	5.17	3.62

Table 65: Body measurements of *Odontotermes* sp.nr. zambesiensis, minor workers, Kajiado nest colony one

n	20	20	20	20	20
Range	1.47-1.67	1.13-1.27	0.27-0.67	0.73-0.87	1.00-1.13
Mean	1.56	1,20	0.43	0.81	1.06
SD	0.07	0.04	0.08	0.04	0.03
CV	4.45	3.35	19.28	4.30	3.11



Imago. Winged males and females. Head sub-circular with moderately dense hairs and with long scattered hairs. Fontanelle region depressed, but fontanelle knob area raised. Frons slopes downwards to clypeal region and characterised by four large light coloured markings. Postclypeus broad with a sub-median line, ante-clypeus nearly rectangular. Ocelli and eyes oval.

Antennae with 19 segments and all hairy. Labrum broad, hairy and tapering anteriorly. Lateral margins smoothly rounded. Mandible bases fairly hairy. Pronotum densely hairy, anterior margin with a small median notch. Lateral margins undulant, posterior margins straight but intercepted by a minute median notch on a raised ridge. Mesonotum with one pair of light coloured markings. Wing length twice as long as the body length. Tibia with strong and enlarged spines, spurs 3:2:2. Legs, sternite and tergites densely hairy. Head of males dark red that of females darker. Eyes black. Antennal segments pale reddish-brown proximally to brown distally. Mandibles pink to red at teeth regions. Pronotum reddish brown. Wings brownish red. Rest of body yellowish brown. Measurements are given in tables 66.

Affinities: Odontotermes sp. nr. zambesiensis is a member of the same group of species as Odontotermes zambesiensis characterized by the fairly straight mandibles with inturned points. Odontotermes zambesiensis stands near Odontotermes patruus, in the elongate rectangular head, but it is much smaller with relatively broader pronotum, slender mandibles and smaller teeth. Odontotermes sp. nr. zambesiensis is bigger than Odontotermes zambesiensis and with a more elongate head capsule.

Table 66: Body measurements of *Odontotermes* sp.nr. *zambesiensis*, alates, males ( $\sigma^7$ ) and female ( $\text{♀}$ ) Kajiado nest colony two

	Head width including eyes	Inter-ocellar distance	labrum max. width	Pronotum		Hind tibia	
				Max. length	Max. width	Max. length	Max. width
$\sigma^7$							
n	7	7	7	7	7	7	7
Mean	3.15	1.84	1.33	1.51	3.15	3.20	0.33
SD	0.17	0.14	0.08	0.09	0.11	0.15	0.00
CV	5.53	7.80	5.95	6.08	3.39	4.67	0.00
$\text{♀}$							
n	10	10	10	10	10	10	10
Mean	3.05	1.78	1.36	1.54	3.09	3.23	0.34
SD	0.09	0.08	0.71	0.07	0.05	0.15	0.03
CV	3.06	4.59	5.21	4.56	1.78	4.79	9.18

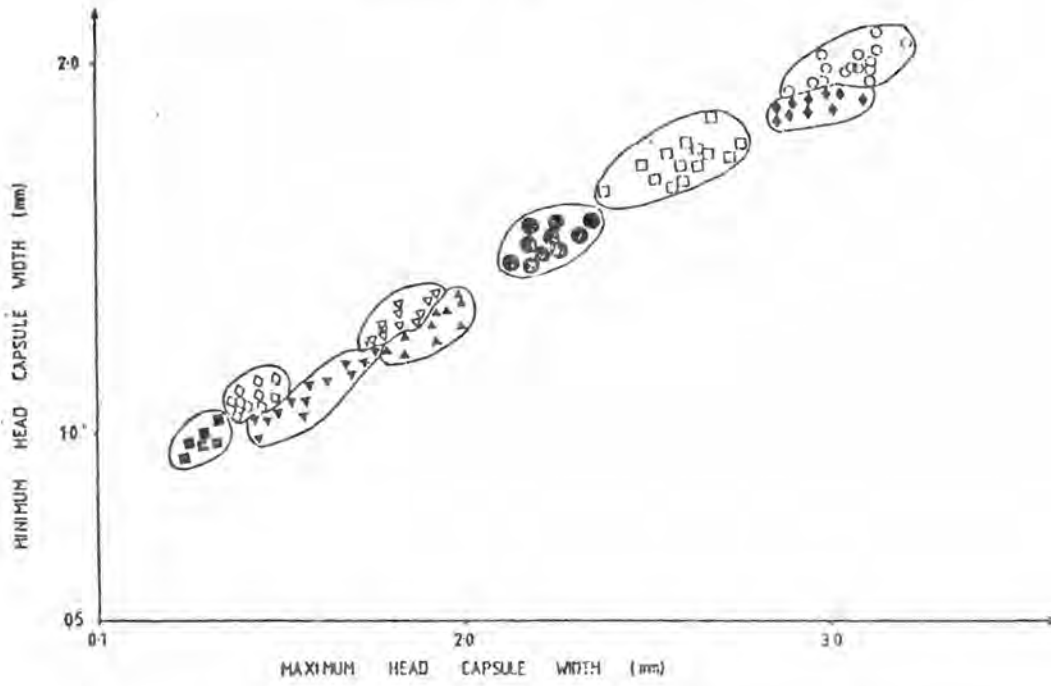
## 5.2.3

## Morphometric Analysis

Body measurements of soldiers, workers and some alates were made. More than 1500 individual termites were examined and 6 to 20 characters were studied from each individual. Tables 3 to 66 in Section 5.2.2.) give summaries of the data obtained from all the individual termites measured from the study area.

The morphometric analysis of Odontotermes species was undertaken, because it was found that the soldiers are so alike morphologically that they are difficult to separate into different species. Attempts to separate species using ratios were tried, but none of them gave a satisfactory separation of all the groups studied. Further analysis was made by plotting the raw data of one character at a time against another for all the individuals measured. It was found that only three characters, head capsule width, head capsule depth and hind tibia width gave reasonable separation on scatter diagrams. The separation of Odontotermes species on the basis of these three characters is shown in figures 15, 16, and 17. Similar measurements of type specimens made during this study were plotted on one of the graphs (Figure 16, shown in small letters) for the purpose of comparing my specimens with the type series.

Fig. 15. Separation of *Odontotermes* species on the basis of maximum and minimum head capsule width



KEY:

○ ○ *O. sp. nr. monodon*

◆ ◆ *O. sp. nr. badius*

□ □ *O. sp. nr. kibarensis*

● ● *O. amaniensis*

△ △ *O. patruus*

▲ ▲ *O. montanus*

▽ ▽ *O. sp. nr. zambesiensis*

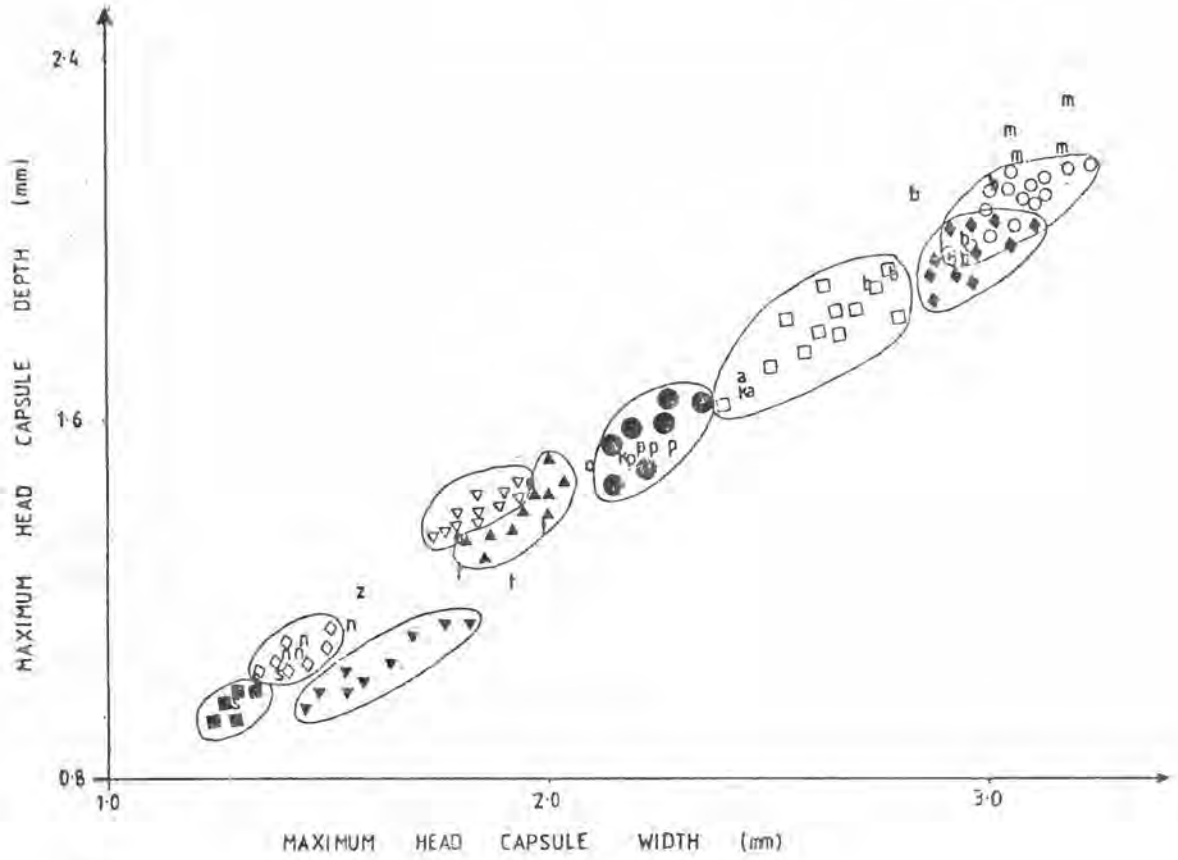
▼ ▼ *O. sp. nr. tanganicus*

◇ ◇ *O. nolaensis*

■ ■ *O. stercorivorus*



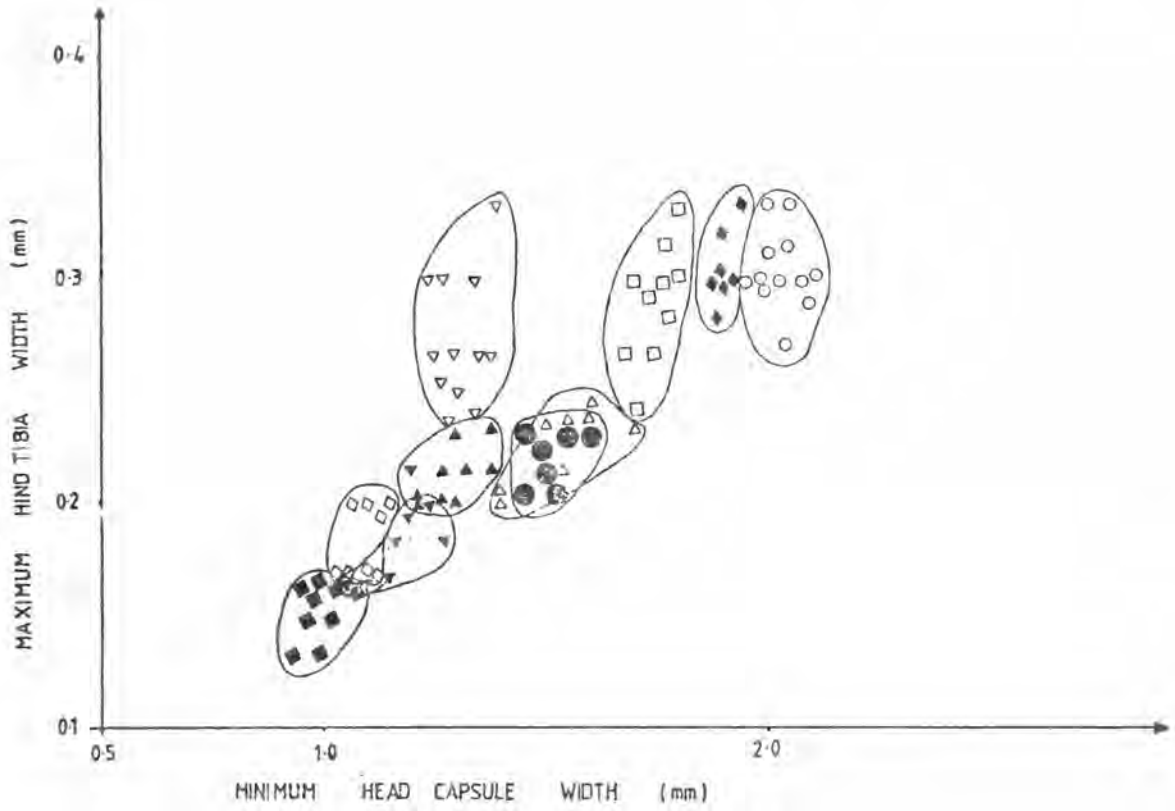
Fig. 16. Separation of *Odontotermes* species on the basis of head capsule width and depth. Letters refer to type specimens.



KEY:

- |                           |                                |                         |
|---------------------------|--------------------------------|-------------------------|
| <i>O. sp. nr. monodon</i> | <i>O. sp. nr. zambesiensis</i> | <i>O. amaniensis</i>    |
| <i>O. sp. nr. badius</i>  | <i>O. sp. nr. tanzanicus</i>   | <i>O. patruus</i>       |
| <i>O. kibarensis</i>      | <i>O. nolaensis</i>            | <i>O. montanus</i>      |
| <i>O. amaniensis</i>      | <i>O. stercorivorus</i>        | <i>O. zambesiensis</i>  |
| <i>O. patruus</i>         | <i>O. monodon</i>              | <i>O. nolaensis</i>     |
| <i>O. montanus</i>        | <i>O. badius</i>               | <i>O. stercorivorus</i> |
|                           | <i>O. kibarensis</i>           |                         |

Fig. 17. Separation of *Odontotermes* species on the basis of head capsule width and hind tibia width.



KEY:

○ ○ *O. sp. nr. monodon*

▲ ▲ *O. montanus*

◆ ◆ *O. sp. nr. badius*

▽ ▽ *O. sp. nr. zamboiensis*

□ □ *O. kiharensis*

▼ ▼ *O. sp. nr. tanganicus*

● ● *O. amaniensis*

◇ ◇ *O. nolaensis*

△ △ *O. patruus*

■ ■ *O. stereorivorus*

In common with the majority of termites Odontotermes identification relies mainly on features of the soldiers (Sterile) and very little on the alate (winged reproductives) castes. However, in some cases workers have been used. For example Kushwaha (1962) gave a detailed account of the characteristic bristles observed on the oral appendages and the the thoracic tergites in the soldier and the worker castes of three Odontotermes species in India.

Within the 'badius' group, Odontotermes badius has long been confused with Odontotermes sp. nr. badius (described on page 89) and with Odontotermes kibarensis by earlier workers. This is partly due to their morphological and external nest structure similarities. I have been able to separate these species through thorough studies and examinations of each species under the stereomicroscope (see descriptions on pages 59 - 63 and 89 - 111). Odontotermes specimens collected from East Africa were compared with Odontotermes badius type specimens and were found to differ in their general shape and size especially in soldier and worker castes. Morphometric analyses summarized in Figure 16 also indicate some character differences. The type locality of Odontotermes badius is in Natal, South Africa and none of the East African species described by Sjostedt 1914 as Odontotermes badius matches Haviland's 1898 type

area when compared with the type series from Kibara and Kampala matches very well. In addition nests structures and termites studied in Uganda (unpubl. report) compare very well with Odontotermes kibarensis of the study area.

The measurements of head capsule of Odontotermes montanus, Odontotermes sp. nr. tanganicus and Odontotermes sp. nr. zambesiensis are very similar and tend to overlap (Fig. 15). However, in figure 16, Odontotermes sp.nr. tanganicus separate from the rest. This means that the head depth and width are useful characters for distinguishing Odontotermes sp.nr. tanganicus from Odontotermes montanus and Odontotermes sp.nr. zambesiensis. On the other hand Odontotermes Sp.nr. badius and Odontotermes sp. nr. monodon (Fig. 16) overlap in some of their morphological measurements but separate in others (Fig. 15 and 17). In Figure 17, Odontotermes sp.nr. monodon, Odontotermes sp. nr. badius, Odontotermes kibarensis and Odontotermes sp.nr. zambesiensis separate without any overlap on the basis of their hind tibia width and head capsule minimum width. However, the morphometrics of Odontotermes sp. nr. tanganicus overlap those of Odontotermes montanus, Odontotermes nolaensis and Odontotermes stercorivorus. The morphometrics of Odontotermes amaniensis and Odontotermes patruus are very similar and these species can only be distinguished by their general shape (see chapter 5). Measurements of those species of Odontotermes identified as near type (for example, Odontotermes sp.nr. monodon, Odontotermes sp. nr. tanganicus and Odontotermes sp. nr. zambesiensis differ markedly from type series (Figure 16).



## CHAPTER SIX

PRINCIPAL COMPONENTS ANALYSIS (PCA) OF  
MEASUREMENTS OF SOLDIER CASTE

## 6.1

## Material and Methods

Fifteen variables were selected as being possible diagnostic characters and were measured on each soldier termite (see chapter five) and analysed using principal component analysis (PCA). These measurements were grouped into two classes according to the two groups of Odontotermes namely "badius" and "tanganicus" which were recognised by their morphological differences (see page 45). Species belonging to the "badius" group are as follows:-

Odontotermes amaniensis, Odontotermes sp. nr. badius,

Odontotermes kibarensis and Odontotermes sp. nr. monodon.

Those belonging to the "tanganicus" group include Odontotermes

montanus, Odontotermes nolaensis, Odontotermes patruus,

Odontotermes stercorivorus, Odontotermes sp. nr. tanganicus and

Odontotermes sp. nr. zambesiensis.

The principal components ('R'-type) analysis of a correlation matrix based on coded characters data was statistically more appropriate for my study than 'Q'-type analysis. However, Gower, (1966) pointed out that the "Q"-type approach of Principal coordinate analyses based on a similarity matrix is mathematically equivalent to the 'R' - type but is computationally simpler and statistically more appropriate when many qualitative variates are included. The numerical characters used for multivariate analysis in my investigation did not include qualitative variates but only quantitative variates.

#### 6.1.1. Basic technique of Principal Components Analysis

The PCA has been used widely in numerical taxonomic studies and displays the relationships between Operational Taxonomic Units (OTUs) in a multi-dimensional space. Thus it enables direct visual examination of the relative positions of the OTUs. The basic technique of PCA is well described by Dunn and Everitt, (1982); Jeffers, (1967); Kendall, ( 1957); Seal, (1964) and many others. The objects of a PCA applied to taxonomic problems may be summarised as follows:-

- (a) examination of the correlations between the separate variables,

- (b) reduction of the variability to the smallest number of meaningful dimensions,
- (c) elimination of variables which contribute relatively little extra information to the study,
- (d) examination of the taxonomic groupings of the individuals,
- (e) determination of the objective weighting of the variables in the construction of taxonomic indices,
- (f) the identification of individuals of doubtful or unknown origin,
- (g) the elimination of misidentified specimens.

Not all of these objectives outlined above will be of equal importance in any particular study, and some may be entirely absent. However, the method provides one possible solution to such problems.

Both unstandardized and standardized dispersion half-matrices, latent roots, normalised eigenvectors, principal component scores, scaled eigenvectors, unrotated factor scores and percentage variance are obtained in this analysis. A maximum of ten components which accounted for most of the variance were obtained. The scores were used to plot component scatter diagrams.

Measurements of soldiers were subjected to two component analyses. The first two used the raw data and the second its logarithmic transformation. The purpose of the latter was partly to reduce bias in weighting of the characters arising from fairly large size differences among them. In addition, it was desired to test the idea that pattern of variation might be at least as well expressed by ratios as by linear functions of the variables. The weighting coefficients of the second analysis were almost identical with the first suggesting that there was little likelihood of biased weightings arising from size differences.

The principal components analysis called for the extraction of the latent roots and vectors of a matrix. The vectors provided weighting coefficients by which the transformation of the variables (characters) to the new set of coordinates was achieved. In PCA either the variance - covariance matrix or the correlation matrix is used. In the latter case the variables are standardized, being expressed in standard deviation units with a variance of 1. The latent roots, the component scores, scaled eigenvectors (unrotated factor matrix) and unrotated factor scores are not given in



full to save space. However the dispersion half-matrices of both "badius" and "tanganicus" groups are given in tables 67 and 68. All the variables are highly correlated except number fifteen.

The values of the eigenvectors are given in tables 69 and 70 for "badius" and "tanganicus" groups respectively. The first two components in "badius" and "tanganicus" groups account for about 86 and 96 percent of the total variability respectively. These would be regarded as being of practical significance. Interpretation of the weighting may then be attempted fairly simply by considering those variables which have relatively high positive or negative weighting as constituting an index of the combined action, or contrast of the original variables. The percentage variance of the principal components of the "badius" group are as follows:-

Principal Component	<u>Percentage variance</u>
1	79.494
2	6.242
3	4.091
4	2.149
5	1.782





6	1.223
7	1.135
8	1.025
9	0.822
10	0.602

The principal component analysis for the "tanganicus" group revealed that almost all 15 variables are equally weighted in the first PCA. The percentage variance of the 10 Principal Components are as follows:-

<u>Principal Component</u>	<u>Percentage variance</u>
1	93.025
2	3.549
3	0.380
4	0.585
5	0.407
6	0.387
7	0.336
8	0.258
9	0.105
10	0.095

The first component gave high positive weighting to the head width, mandible length, antennal foveolar distance, head depth and hind tibia length which may be regarded as a general index of the size of the Odontotermes species. The second



component gave high weight only to hind tibia width, mesonotum and metanotum width which may be a measure of shape. In the "badius" group, normalised eigenvectors of all the ten principal components analysed, show hind tibia width to have the lowest weighting variables. On the other hand, antennal foveolar distance was highly weighted in the first component (table 69). Similarly in "tanganicus" group, hind tibia width has the lowest weighting, while hind tibia length and mandible length are highly and equally weighted (table 70). In tables 69 and 70 the first fourteen variables are highly correlated but the fifteenth variable, hind tibia width is independent.

Since the two analyses of soldier castes were nearly identical only the standardized measurements were used for principal component scatter plots. The values of the first two components are plotted in figures 18 and 19, the first and second components being plotted on the horizontal and vertical axes respectively. In Fig. 18 Odontotermes sp. nr. monodon seems to be closely related to Odontotermes sp. nr. badius while the other two, Odontotermes kibarensis and Odontotermes amaniensis stand out as distinct species. Odontotermes stercorivores, Odontotermes nolaensis and Odontotermes sp. nr. nolaensis (the PCA has separated this group from the rest of the nolaensis nest colonies) are very closely related and their morphometrics overlap (Fig. 19).

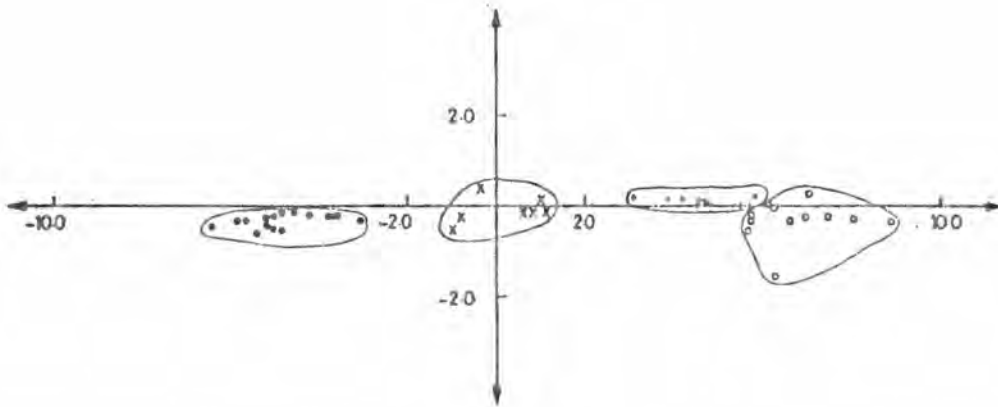
Table 69: Normalised eigenvectors "badius" group

<u>Variable</u>	<u>Principal components</u>									
	1	2	3	4	5	6	7	8	9	10
Head max. length	0.251	-0.013	0.041	-0.019	0.940	-0.040	0.149	-0.009	0.105	0.022
Head max. width	0.274	-0.021	-0.040	-0.045	0.009	0.123	-0.467	0.001	-0.460	-0.423
Head min. width	0.281	-0.029	-0.060	-0.057	0.006	-0.087	-0.013	0.092	-0.040	-0.061
Head max. depth	0.277	-0.049	-0.109	-0.122	0.060	0.241	-293	0.045	-0.269	0.069
Gula max. width	0.234	-0.077	-0.597	-0.412	-0.127	0.415	0.406	0.070	0.110	0.032
Left mand. max.length	0.280	0.018	0.038	-0.004	-0.127	-0.328	0.266	0.156	0.086	-0.370
Right mand.max.length	0.279	0.002	0.048	0.029	-0.127	-0.354	0.202	0.181	0.110	-0.377
Left tooth distance	0.213	-0.097	0.749	-0.536	-0.127	0.214	0.106	-0.038	0.051	0.112
Ant.fove.distance	0.284	-0.030	-0.046	-0.048	-0.027	-0.172	-0.149	-0.052	-0.098	0.032
Pronotum max. width	0.268	0.005	0.024	0.222	-0.074	0.182	-0.425	0.494	0.602	0.179
Mesonotum max. width	0.262	0.004	0.157	0.567	-0.127	0.346	0.296	-0.210	-0.022	-0.087
Metanotum max. width	0.274	0.020	0.081	0.347	-0.024	0.239	0.142	-0.210	-0.129	0.139
Hind tibia max. length	0.273	-0.017	-0.047	0.069	-0.118	-0.395	0.123	0.202	-0.367	0.669
Hind tibia max.width	0.084	0.989	0.008	-0.107	-0.011	0.043	-0.005	-0.018	0.001	0.029

Table 70: Normalised eigenvectors "tanganicus" group

Variable	Principal components									
	1	2	3	4	5	6	7	8	9	10
Head max.length	0.258	-0.270	0.214	-0.053	0.273	-0.236	0.274	-0.387	-0.400	0.202
Head max. width	0.256	-0.362	-0.195	0.113	0.093	-0.034	0.122	-0.056	0.026	-0.034
Head min. width	0.262	-0.193	0.110	-0.046	0.247	-0.037	0.098	-0.418	0.576	-0.124
Head max. depth	0.261	-0.083	0.183	-0.218	-0.562	-0.320	0.051	0.066	0.324	0.260
Gula max. width	0.251	-0.365	-0.064	0.258	-0.378	0.579	-0.390	-0.231	-0.090	0.003
Gula min. width	0.257	0.001	0.643	0.066	0.115	0.425	0.314	0.464	0.014	-0.061
Left mand. max.length	0.265	0.107	-0.156	-0.194	-0.201	-0.044	0.083	0.139	0.009	-0.109
Right mand max.length	0.265	0.061	-0.135	-0.171	-0.224	-0.072	0.107	0.131	0.048	-0.152
Left tooth distance	0.258	0.081	-0.601	0.15	0.241	0.262	0.370	0.166	0.108	-0.049
Anten.fove.distance	0.254	-0.322	-0.029	0.104	0.329	-0.363	-0.532	0.499	0.019	-0.113
Pronotum max.width	0.261	0.243	0.138	-0.189	0.016	-0.037	-0.156	-0.202	-0.391	-0.498
Mesonotum max.width	0.254	0.400	0.041	-0.176	0.076	0.055	-0.257	-0.173	0.168	-0.241
Metanotum max.width	0.257	0.327	-0.014	-0.199	0.275	0.190	-0.309	-0.207	0.008	0.695
Hind tibia max. length	0.265	-0.026	-0.163	-0.072	-0.193	-0.097	0.133	0.099	-0.445	0.172
Hind tibia max.width	0.246	0.409	0.036	0.822	-0.091	-0.257	0.066	-0.076	0.032	0.859

Fig. 18. Principal components analysis of body measurements of Odontotermes species. Standardised data, "badius" group, 15 characters, 63 otus. Horizontal axis is the first component; vertical axis is the second component.



KEY:

○ ○ O. sp. nr. monodon

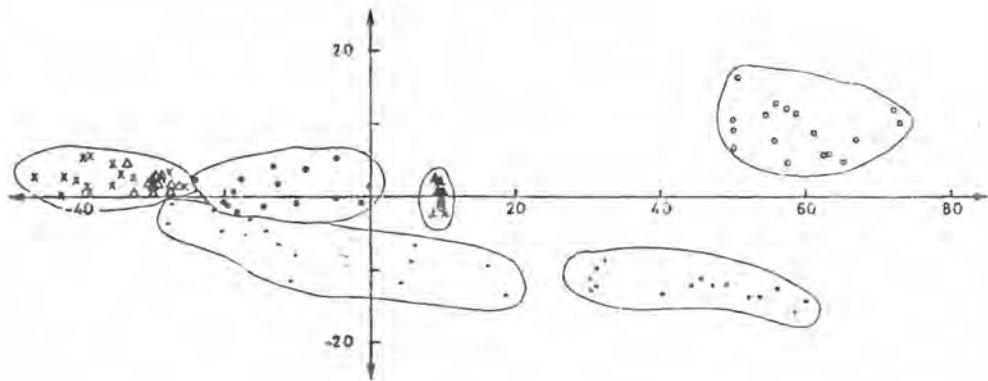
+ + O. sp. nr. badius

x x O. kibarensis

● ● O. amaniensis



Fig. 19. Principal components analysis of body measurements of Odontotermes species. Standardised data, "tanganicus" group, 15 characters, 95 otus. Horizontal axis is the first component; vertical axis is the second component.



Key:

	<u>Locality</u>
••	<u>O. nolaensis</u> - Langata
•••	<u>O. sp. nr. nolaensis</u> - Ruaraka
ΔΔ	<u>O. stercorivorus</u> - Kileleshwa
ΔΔΔ	<u>O. montanus</u>
•••	<u>O. sp. nr. zambesiensis</u>
xx	<u>O. stercorivorus</u> - Ruaraka
o°o	<u>O. sp. nr. tanganicus</u>

Principal components analysis worked out on Odontotermes measurements has given further suggestions to deal with taxonomic problems in Odontotermes species.

The very high degree of correlation between almost all the variables except hind tibia width was entirely unexpected (see dispersion half-matrix of "badius" and "tanganicus" groups in tables 69 and 70) and it is clear that very few basic dimensions of the individuals have been measured by this large group of variables. The hind tibia width which is accounting for the large difference in the analysis is unique and therefore it is an important variable in Odontotermes species. It is clear from the analysis that new variables, uncorrelated with those of the present study, should be sought in further work. The plotted data in figures 18 and 19 suggest that there are four and six major taxonomic groups respectively, recognisable by differences in their general size and shape. The recognition of these ten groups probably corresponding to species, is facilitated by the identification and interpretation of the components. The variables which were given a major importance in the PCA include head capsule length and width, mandible length, antennal foveolar distance, metanotum width and hind tibia length and width. These variables may be considered for future use whenever taxonomic studies of Odontotermes species are carried out.

## CHAPTER SEVEN

GENERAL DISCUSSION AND CONCLUSION7.1 Biochemical characterization of Odontotermes species

Biochemical techniques are now being applied to systematic problems of all types and in many different organisms. Systematic information relatively free of environmentally induced changes can be obtained by examining either the base sequence in DNA or the sequence of amino acids in proteins, the primary products (Ferguson 1980). Of all the methods of biochemical systematics, the most widely used is electrophoresis. In general terms electrophoresis is the movement of charged particles under the influence of an electric field. All proteins carry an electric charge which is determined by their amino acid composition and the PH of the medium.

In order to stabilize the charge, electrophoresis is carried out in a buffer or series of buffers. Although electrophoresis has been widely used in many different organisms, none as far as I am aware has been done previously on Odontotermes. During this study of Odontotermes taxonomy, some time was spent trying to characterise Odontotermes

proteins using electrophoresis. The idea was to utilise the isoenzyme technique in addition to other taxonomic methods to distinguish closely related species of Odontotermes.

The results however did not differentiate clearly between species of Odontotermes. The isoelectrofocusing patterns of the selected isoenzymes were not clear. Because electrophoretic data were no help in my investigation of Odontotermes taxonomy, I have decided to exclude biochemical investigations in my discussion. However, material and methods used and results obtained have been put into the appendix.

#### 7.2.. Field Identification of Termite species

Detailed field studies on african termites have mainly centred on mound building species. This is because they are more conspicuous than non-mound building or subterranean species. Because of their ecological importance many workers (e.g. Bouillon and Kidieri, 1964; Darlington, 1984; Fuller, 1915; Johansson and Stromquist, 1977; Michelmore, 1939; Mielke, 1978; Noirot, 1970; Troll, 1936; Vesey-Fitzgerald, 1963; Zonnevelt et al, 1971) have studied various aspects of large african termite mounds. Conical mounds have been associated with nests of higher termites (Macrotermitinae) of the genera Macrotermes (e.g. Bodot, 1971; Burtt, 1942; Hesse, 1955; Lepage, 1972; Pomeroy, 1977; 1983), or Odontotermes (Darlington, 1985b; Glover



et al, 1964; Kemp, 1955). Abundance of termite mounds has been noted in different types of vegetation. For example Sands (1965) recorded nine mound building species in climax woodland, eight in partly cleared woodland and six in totally cleared areas in Northern Nigeria. Similarly it is likely that cleared or grazed areas affect Odontotermes mound abundance. Although there were no detailed studies to assess the number of Odontotermes mounds in various habitats studied personal observations suggested that cleared areas contained less mounds than in uncleared areas. Wood et al (1982) have pointed out that there are qualitative and quantitative changes in the termite fauna when tropical woodlands and savannas are partly or completely cleared for pastoral or agricultural purposes. Whether these changes affect the nest architecture or species diversity needs further investigation.

Many workers have used field observations to distinguish various species of termites. The size of the nest is quite often fairly characteristic of the species. Emerson (1938) and Fuller (1922) used a synopsis of their habits to recognise termite species in the field. In East Africa, Van der Werff (1981) described two types of mounds built by Macrotermes species. Darlington (1977) and Pomeroy (1983) distinguished two types of mound ('Open and Closed') built by Macrotermes species in Kenya and Uganda. Collins (1979) described two

rather different sympatric nest types of Macrotermes bellicosus (Sneathman) in Nigeria. Mound structures have been used to separate closely-related species of Odontotermes in India by Roorwal & Rathore (1978) and Chhotani (1981).

Odontotermes mounds range in size from small conical structures only a few centimetres in height and diameter to large mounds built by the "badius" group. The classical Odontotermes mound has been described many times (e.g. Darlington in preparation; Grasse' and Noirot, 1950; Hartwig, 1966). It consists of a low wide mound often over-grown with vegetation, into which penetrate a variable number of open vertical shafts of circular or oval cross-section. The shafts always interconnect below ground level (see Figure 3 and plate 15). In general Odontotermes mounds vary considerably in their shape and size due to abiotic and biotic factors prevailing within their habitats. For example although live termite mounds are always being enlarged and repaired, they continually get eroded by rainwater or by animals.

The nest structures are a morphological expression of behaviour patterns and the nest forming behaviour is predominantly an inherited species pattern (Emerson 1938). The nests of a given species show striking similarity in material, general shape, internal organization and ecological position. Examination of the internal structure of Odontotermes nests

shows clearly that air passages do not open into the fungus chambers. On the other hand foraging holes or galleries do open into the fungus chambers. The colour of fungus combs in Odontotermes differs between and within species. Probably this is due to food and soil particles taken by the workers, and due to the age of the fungus combs and the rate at which fungi belonging to the genus Termitomyces decompose the plant material from the combs. For example fresh fungus combs deposited on top of the older one appear dark coloured but turns to light colour after a few days in the fungus chamber (personal observations).

The internal layout of the ventilation systems and the size and distribution of the fungus chambers around them are basically similar but distinctly different in each species studied. For example Odontotermes sp. nr. monodon fungus combs are ovoid and firm in texture with smooth plastered walls (see plate 8) while that of Odontotermes sp. nr. zambesiensis are elongate ovoid, very fragile and difficult to handle especially when fresh. The laminae are parallel and curve down at the edge so that from below the edge of the lamina appear as concentric circles (see plate 18). Similarly Odontotermes montanus fungus combs are of complicated shape and very fragile with thin walls. Usually O. montanus fungus combs are



joined together within the nest chambers to form a massive central fungus comb surrounding the royal cell. However, in general Odontotermes fungus combs assume a cake-like structure inside the fungus chambers which are distributed within the nest.

A method which may separate closely related species worthy of mention, although not studied on Odontotermes species is the swarming flights of reproductives. This isolating mechanism has been observed in other termites species but there are no published records of this nature on East African species. This method could be applied to East African Odontotermes as it is in Microtermes species of West Africa (Wood, 1981). However there were detailed observations made as regards Odontotermes swarming flight times, but the few species observed indicate that Odontotermes species fly a few days after it has rained in the April-May or October-November rainy seasons. Some fly at night whilst others fly in the daytime. For example both Odontotermes kibarensis and Odontotermes nolaensis which are not closely related fly during and after heavy rain in the morning and evening period. However, although some observations on flight periods have been reported in West Africa on other termite genera (Sands, 1965; Josens, 1972; Roy-Noel, 1972; Wood, 1981) there are few indications as to how effective they are in isolating closely-related species.



### 7.3 Morphological Similarities and Differences in Odontotermes species

In Odontotermes species, intraspecific variation occurs within the population of the same colony and also between different colonies. Intra-colonial variation (in characters such as chaetotaxy, body size, coloration etc) may be very different from that observed between colonies (Roonwal, 1978). There is an extremely wide range of intraspecific variation with regard to size and proportions of the head in Odontotermes soldiers, while on the other hand they only vary interspecifically with regard to the position of the tooth (Thakur, 1981). Because of the wide range of intraspecific variation and very limited interspecific variation, resulting in lack of reliable taxonomic characters in Odontotermes, the systematist has the unfortunate choice of adding on the one hand to an already swollen list of species or underestimating characters of taxonomic value.

The distinction between Odontotermes species is mostly based on morphological criteria involving size, colour, pilosity and sometimes wing venation. The shortage of other

characters has led taxonomists to make increasing use of measurements in studying termites. This has developed very largely on a trial and error basis and a large number of differing measurements and ratios (indices) have been employed. Roonwal (1964) noted that 66 measurements and 34 indices had been published and suggested a further 22 and 19 respectively bringing the total to 88 measurements and 53 ratios. He recognised that such numbers were impractical and selected 32 measurements and 18 indices as being sufficiently sensitive for general use. There has been some published discussion on the number of individuals of any species or colony series that should be measured to obtain a representative sample for statistical purposes. Bouillon (1966) concluded that six to ten specimens were sufficient, Sands (1972) concluded from preliminary tests with common, well represented species, that for the purpose of multivariate analyses it was adequate to measure one or two specimens of each caste from each colony of soldierless termites.

Chhotani (1981) carried out morphometric analyses of the populations from four different types of Odontotermes obesus mounds to determine whether the populations can be differentiated

statistically. He picked two samples each of twenty five soldiers from these four mounds and measured seven characters and determined ten ratios for statistical analysis. The populations from the different mounds A, B, C and D were compared with each other. He found that soldiers from the intra-mound populations of the different types of mounds, were significantly different in each of the four Odontotermes mounds indicating that a great deal of morphological variation occurs in the soldier caste. Similarly in the inter-mound comparisons he found that the soldier populations could be statistically separated. In the current study, the morphometric analysis of the soldier caste, using fifteen body measurements from each soldier and ten to eighteen individuals from each nest colony, has allowed nine species to be separated (Fig. 15 and 16).

An application of the principal components analysis in termite systematic was used by Sands (1972) on the soldierless termites of Africa. Apart from this work on soldierless termites and the present study there are no other PCA analyses as far as I am aware, which have been conducted on termites to enable comparisons to be made. There is a need for the technique to be more widely applied, and perhaps even more important, for the results of these applications to be more widely reported within the contexts of their original

problems. In my study PCA has demonstrated that closely related species can be separated without overlap in their body measurements (fig.18 and 19) as compared to the results shown in figures 15 - 17.

#### 7.4 Comparison of Type Specimens with East African Odontotermes Material

The workers, imagos and soldiers from the majority of Odontotermes species are so alike morphologically that they are difficult to separate into different species. My comparisons of the available material of Odontotermes with the type specimens indicated that in many cases, incorrect names have been used to identify species. For example, nearly all the nest series labelled as 'Odontotermes latericius (Haviland, 1898)' in the BMNH, London collection, do not resemble the type specimen, but match Odontotermes lacustris Harris, 1960, which has never previously been recorded in East Africa. This is also true for specimens labelled as 'Odontotermes badius (Haviland, 1898)' which appears to fall within the morphometric range of Odontotermes kibarensis (Fuller, 1925). The collection does not seem to have genuine east African representatives of Odontotermes anceps (Sjöstedt, 1911); Odontotermes fallax Sjöstedt, 1907; Odontotermes rectanguloides Sjöstedt, 1924, or Odontotermes terricola



(Sjöstedt, 1902), although there are nest series erroneously labelled with these names. It is difficult to distinguish between the type specimens of Odontotermes nolaensis Sjöstedt, 1924 and Odontotermes stercorivorus (Sjöstedt, 1907) which show the same characteristics with very slight variations. Odontotermes latericius and Odontotermes mediocris (Sjöstedt, 1911) are only distinguishable by size differences.

This study leaves a lot of questions unanswered about the taxonomic status of Odontotermes. Probably Odontotermes nolaensis is a synonym of Odontotermes stercorivorus and Odontotermes mediocris may be a synonym of Odontotermes latericius. These will certainly be rectified when a full revision of the genus in the region is completed. In addition ten species of Odontotermes were found to occur in the study area and of these, four (see section 5.2.2) species did not match with the type series hence I believe they are new species which have not been described from anywhere in Africa. These findings in a small area of Kenya give strong evidence that the African fauna is not yet fully known.

Termites, together with other insects and related arthropods, destroy more than one-third of the world's potential agriculture yield. Members of the genus Odontotermes are ecologically diverse, some of them being pests of crop plants and timber, and some being significant as decomposing, mound building and soil conditioning organisms. The first step in any rationally planned attempt to control termites or any other insect pests is the accurate identification of the organism concerned. For example chemicals, resistant varieties, predators and parasites, pheromones, lethal genes etc. used as pest control agents may be highly species-specific and can succeed only if the identity of the pest is accurately determined. Where a crop is being attacked by several species of termites, some of which build mounds, only part of the damage may be controlled by pest control agents. Often when mounds are present, only the subterranean non-mound-building species damage crops and to poison the mounds would be a waste of effort. It is therefore very important to have accurate identification of the pest species before control is attempted.

This study has covered useful taxonomic aspects of the genus Odontotermes in a part of East Africa. I believe this background information will speed up the entire revision of the genus, where more investigations of nest structures and

possibly isoenzyme work will be emphasised. For example this study has shown that in some of the species the differences of fungus combs are sufficiently distinct to discriminate the species with confidence. The morphological characters which are most likely to be useful in Odontotermes taxonomy especially from soldier castes include head capsule width, head capsule depth, antennal foveolar distance, tooth distance from the mandibular tip, pronotum or mesonotum width, hind tibia width and length. Integration of various techniques; biochemical, morphological and nest structure studies will definitely resolve the taxonomic difficulties of the African genus Odontotermes.

7.6 A PRELIMINARY KEY TO EAST AFRICAN ODONTOTERMES SPECIES  
 BASED ON THE SOLDIER CASTE

The key uses a set of measurements and indices which are essential for discrimination between species. The characters concerned are: Head depth (hd); head width maximum (hw max) and minimum (hw min); antennal foveolar distance (afd); mandible length (ml); mandible tooth distance (mtd); hind tibia length (tl); (fig. 4, page 80). The methods used for studying all characters are described in chapter five and the descriptions of East African Odontotermes species are given in sections 3.2 and 5.2.2.. Species keyed below include all those species recorded and studied outside study areas. The indices are as follows:

1. ml/tl (mandible-tibia index)
2. mtd/ml (mandibular tooth index)
3. hd/hw max (head capsule index I)
4. hw min/hw max (head capsule index II)
5. afd/hw max (Antennal foveolar-head index)

1. Head elongate rectangular to subovate; mandibles stout, both mandibles always with prominent median tooth; large species with head length including mandibles more than 2.5 mm.....2



- Head pyriform to ovate; mandibles slender, right mandible with a minute or vestigial median tooth; small to medium-sized species with head length including mandibles less than 2.5 mm..... 20
  
- 2(1) Head length including mandibles more than 3.5 mm; Head length exceeding maximum head width by less than a quarter of its measurements. Frons with short sulcus and median ridge or with minute papillae; antennae 17 - 18 segments.....3
  
- Head length including mandibles less than 3.5 mm. Head length exceeding maximum width by more than quarter of its measurements. Frons smooth, antennae 16 - 18 segments .....12
  
- 3(2) Frons with definite frontal ridge; sulcus deep; area surrounding fontanelle spot and ridge deeply depressed.....4
  
- Frons without frontal ridge, or at most with minute papillae, sulcus shallow, depression around fontanelle spot shallow.....7

- 4(3) Head with posterior corners smoothly rounded, ratio of hw min to hw max, 0.30 - 0.40; labrum with sides arcuate; antennae with 18 segments; gula length less than twice its width; hw max 3.00 - 3.20 mm.....monodon
- Head with posterior corners sinuate, ratio of hw min to hw max more than 0.45; labrum rectangular gula length twice its width.....5
- 5(4) Head with parallel sides curving smoothly anteriorly; pronotum with deep anterior median notches; antennae with 18 segments; gula oval and elongate with arcuate lateral margins; hw max 2.60 - 3.10 mm.....amanicus
- Head sides indented anteriorly from behind antennal sockets; pronotum with shallow anterior median notches; antennae with 17 segments; gula widest across medial region with lateral margins undulant;.....6
- 6(5) Frons with short ridge and conspicuous fontanelle spot; gula with several bristles anteriorly, hw max 2.85 - 3.25 mm.....sp. nr. monodon

- Frons with long ridge and inconspicuous frontanelle spot; gula without or with a few bristles anteriorly; hw max 2.60 - 2.75 mm..... culturarum
  
- 7(3) Frons flat (Fig.6C page 90); mandibles stout scarcely narrowing before apical curve; ml/tl 0.75 - 0.85.....8
  
- Frons raised (Fig.7c page 98); mandibles slender evenly narrowing to form an apical curve, ml/tl more than 0.86.....9
  
- 8(7) Head vertex without hairs; ; labrum tapering anteriorly; pronotum and mesonotum with straight margins; gula with lateral sides undulant and length less than twice the width, hw max 2.70 - 2.75 mm.....badius
  
- Head vertex with few hairs; labrum broadening anteriorly towards the tip; pronotum and mesonotum with irregular margins; gula with parallel sides and length more than twice the width; hw max 2.58 - 3.20 mm.....sp. nr. badius

- 9(7) Frons smooth without grooves and fontanelle spot invisible; left mandible with median tooth projecting at acute angle to inner margin of the mandible; gula rectangular widening posteriorly,  
hw max 2.25 - 2.35 mm.....fallax
- Frons rough usually with grooves and conspicuous fontanelle spots; left mandible with median tooth projecting at obtuse angle to inner margin of the mandible (Fig.20); gula widest medially;  
hw max 1.85 - 2.90 mm.....10
- 10(9) Frons with minute grooves; mandible bases smooth with no hairs, ml/tl 0.88 - 0.95; hw mh/hw max more than 0.71, hw max 1.85 - 2.39 mm.....patruus
- Frons with conspicuous grooves, mandible bases rough with hairs; ml/tl less than 0.87,  
hw min/hw max less than 0.70.....11



11(10) Mandible with short incurved tips, right mandible with median tooth strongly obtuse and with smooth wavy inner margins proximally, mtd/ml 0.36-0.39; pronotum always wider than mesonotum;

hw max 2.05 - 2.90 mm.....kibarensis

- Mandibles with long incurved tips, right mandible with median tooth weakly obtuse and with sinuated inner margins proximally, mtd/ml 0.40 - 0.45; metanotum wider than pronotum; hw max 1.85 - 2.50 mm.....amaniensis

12(2) Head broadly rectangular, frons flattened; mandibles strong with prominent median teeth, left mandible tooth projecting at right angles to inner margin of mandible; hd/hw max 0.70 - 0.74;

hw max 1.75 - 2.15 mm.....montanus

- Head elongate, rectangular or ovate, frons raised and sloping to clypeal region; mandibles fairly strong, right mandible with or without a prominent tooth, left mandible tooth at acute angle to inner margin of mandible.....13

13(12) Mandible length less than half head length, both mandibles with prominent median tooth weakly at acute angle ( $45^{\circ}$ ) to inner margin of mandibles.....14

- Mandible length more than half head length, left mandible with median tooth strongly at acute angle ( $45^{\circ}$ ) to inner margin of mandible, right mandible with a minute tooth.....17

14(13) Left and right teeth near apical third, right tooth blade-like proximally,  $mtd/ml$  0.28 - 0.32; frons with conspicuous knob; pronotum posterior margin deeply incised medially; gula widest towards posterior part and with its width more than half its length;  $hw$  max 1.80 - 2.00 mm.....tanganicus

- Left and right teeth medial, right tooth cone-shaped  $mtd/ml$  more than 0.37; frons without conspicuous knob; pronotum with shallowly incised posterior margin; gula narrow posteriorly; width less than half its length.....15

- 15(14) Head with medial-lateral margin indented,  $hd/hw$  max 0.62-0.66 (Fig. 13a page 152); right mandible with median tooth at right angle to inner margin of mandible;  $hw$  max 1.40-1.18mm.....sp. nr. tanganicus
- Head with parallel sides widest medially,  $hd/hw$  max more than 0.75 (Fig. 10a page 126); right mandible with median tooth at obtuse angle to inner margin of mandible (Fig. 20).....16
- 16(15) Head with posterior margin smoothly rounded; gula with straight lateral margins;  $afd/hw$  max 0.80 - 0.81;  $hw$  max 0.95 - 1.20mm.....stercorivorus
- Head with posterior margin abruptly rounded; gula with irregular margins;  $afd/hw$  max 0.81 - 0.83;  $hw$  max 1.20 - 1.40mm.....nolaensis
- 17(13) Gula with straight margins; right mandible with vestigial tooth whose upper edge is at right angles to the inner edge of mandible; antennae with 17 segments,  $afd/hw$  max more than 0.78;  $hw$  max 1.65 - 1.95mm .....sp. nr. zambesiensis

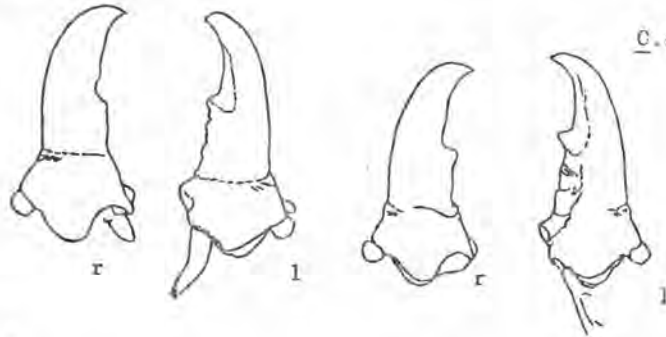
- Gula with constricted margins and narrowed medially;  
right mandible with small tooth whose upper edge is at  
obtuse angle to inner edge of mandible,  $afd/hw$  less  
than 0.78.....18
  
- 18(17) Head sub-rectangular,  $hd/hw$  max 0.76 - 0.79; labrum  
width more than half its length, left mandible without  
notch distal to mandibular tooth base;  
 $hw$  max 1.50- 1.65 mm.....zambesiensis
  
- Head sub-ovate,  $hed/hw$  max less than 0.75; labrum with  
less than half its length, left mandible with notch  
distal to mandibular tooth base.....19
  
- 19(18) Left mandible with medial tooth, apical region smoothly  
tapering,  $mtd/ml$  0.42 - 0.48; right mandible with notch  
proximal to tooth on inner edge;  $hw$  max  
1.50 - 1.70 mm.....boranicus
  
- Mandible with distal tooth, apical region distinctly  
swollen distal to tooth, right mandible without notch,  
 $mtd/ml$  0.32 - 0.36;  $hw$  max  
1.60 - 1.90 mm .....transvaalensis



- 20(1) Head width medially less than vertex head width;  
mandibles long, slender, with sharply incurved tips,  
right mandible with two vestigial teeth, one half-way  
and other near base, right mandible evenly narrowing  
to apical curve, mtd/ml more than 0.26.....21
- Head width medially greater than vertex head width;  
mandibles short and slender slender, right mandible  
without a vestigial median tooth and scarcely narrowing  
before apical curve, afd/ml less than  
0.24. ....22
- 21(20) Left mandible tooth distal, mtd/ml 0.24 - 0.27; hd/hw  
max 0.72 - 0.76; hw max 1.15 - 1.30 mm.....latericius
- Left mandible tooth near medial, mtd/ml 0.30 - 0.34;  
hd/hw max 0.78 - 0.80; hw max 1.31 - 1.54 mm...lacustris
- 22(20) Mandible blades bulding between apical median teeth;  
tips strongly incurved, ml/t1 0.76 - 0.80; hd/hw max  
0.70 - 0.74; hw max 1.00 - 1.30 mm.....sp. nr.mediocris
- Mandibles with outer margin straight and evenly  
narrowing before apical tooth, weakly incurved towards  
the tip, ml/t1 0.82 - 0.87; hd/hw 0.77 - 0.81; hw max  
0.95 - 1.20.....mediocris

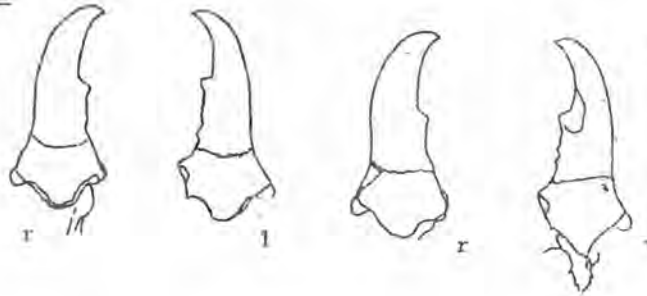
Fig: 20 Drawings of Odontotermes mandibles, ventral plan view (r = right mandible l = left mandible)

O. sp.nr. monodon



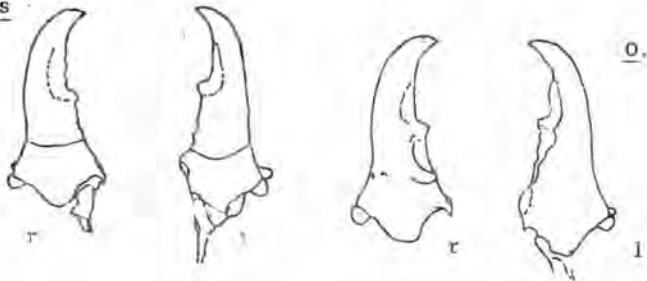
O.sp.nr. badius

O. kibarensis



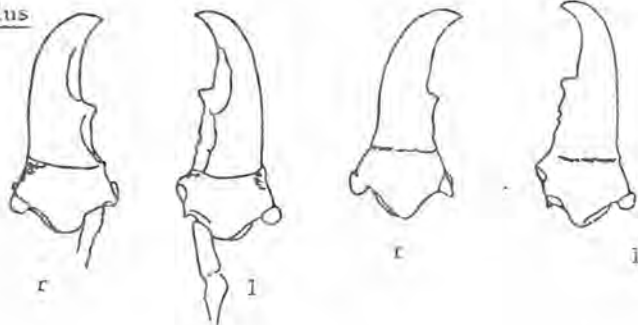
O. kibarensis

O. amaniensis



O. kibarensis

O.sp.nr. badius



O. kibarensis

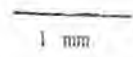
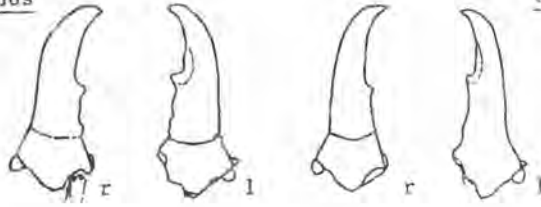


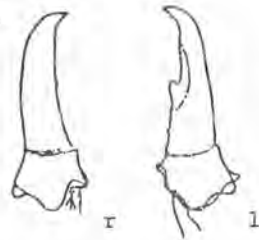
Fig. 20 Continued next page

O. patruus

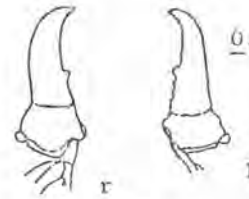


O. montanus

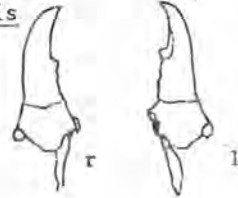
O. sp. nr. zambesiensis



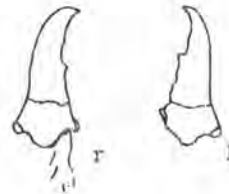
O. sp. nr. tanganicus



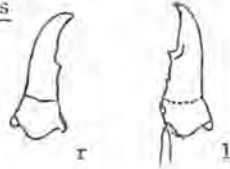
O. nolaensis



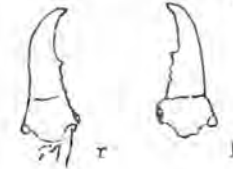
O. stercorivorus



O. stercorivorus



O. stercorivorus



—  
1 mm

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A P P E N D I X



## Biochemical techniques

## Material and methods

Three electrophoretic techniques were used namely:-

- 1) Starch gel electrophoresis
- 2) Agarose gel electrophoresis
- 3) Polyacrylamide gel electrophoresis

Live and active soldier termites were selected, counted, rinsed with distilled water  $\text{dH}_2\text{O}$  dried and weighed. Specimens were then homogenized in buffer or in distilled water using either an electric homogeniser (Dupont Instruments Sorvall Omni-mixer) or a manual homogenizer. The extract or homogenate was then spun (centrifuged) using a Beckman Ultracentrifuge model L5-50. The homogenate was spun at 15000 RPM for 20 minutes at  $0^\circ\text{C}$ . The supernatant was again spun at 15 000 RPM for 30 minutes at  $0^\circ\text{C}$ . Extracted supernatant was stored in liquid nitrogen in the form of  $10\mu\text{l}$  beads until required. Beads from the same sample colony were stored together in a labelled plastic vial in cannisters inside a liquid nitrogen tank.

### Polyacrylamide Gel preparation

Stock solution was prepared by taking 9.7 g acylamide and 0.3 g bis-acrylamide and dissolving them in 100 ml of distilled water by stirring for 1 hour. To prepare sufficient gel for a 115 x 230 mm plate (1 mm thick the following recipe was used:-

15 ml of stock solution

1.9 ml pharmalite

4 ml glycerol

9 ml distilled water

This mixture was deaerated completely under vacuum pump for 15 minutes. Then 400 ml of ammonium persulphate and 100 ml of TEMED were added, before pouring onto a vertically aligned glass plate, arranged as for agarose (above) but without Gel Bond. Introduction of polyacrylamide mixture between the glass plates was by the same technique as for agarose. Many gels were prepared and later kept in the refrigerator at 4<sup>o</sup> Celcius.

## Extraction methods

Samples were homogenised using either distilled water or buffers. Homogenising buffer was prepared by using the following compounds:-

- (i) Dithiothreitol (DTT)
- (ii) E - aminocaproic (E-ACA)
- (iii) Na<sub>2</sub> EDTA
- iv) 1% Triton X 100
- (v) Propanol
- (vi) Phenylmethylsulphonyl-fluoride (PMSF)

30.8 mg of DTT were dissolved in 1 ml EDTA and then added to 26.2 mg E-ACA which was dissolved. This mixture was then kept in the refrigerator as a stock solution. The stock was diluted 1:100 before use by taking 50ml and making it up to 5 ml with 1% Triton X-100 solution in PMSF-proteinase inhibitor which protect proteins from breaking down during processing. The amount added to the samples for extraction depended on their total body weight. A volume equivalent to half or less of their total body weight was used. For example, if one sample weighed 2.00 g the amount of buffer or distilled water used for extraction was 1 ml.

### Gel preparation

10% starch gels were prepared by taking 5.00 g of hydrolysed starch (Connaught starch) and dissolving it into 50 ml of diluted buffer. This mixture was heated in a conical flask while being stirred with a magnetic stirring rod. When the solution became clear on boiling the whole content was poured onto a clean plate (15 x 22) on the labelling table, and spread evenly over the plate using a gel spreader. A layer of gel 1 mm thick was formed on the plate. Several gel plates of this kind were prepared in the same manner and left to polymerise on the bench, and later transferred in the refrigerator at 4<sup>o</sup> Celcius.

### Agarose gel preparation

3.60g of sorbitol and 0.30 g of agarose were weighed and added 25 ml of distilled water and dissolved using a magnetic stirrer in a boiling water bath. When dissolved and ready for casting, 2 ml pharmalyte were added. Mould preparation was carried out on a spirit levelled table covered by clean dry glass plate (15 x 22 cm). A sheet of Gel Bond with the hydrophilic surface uppermost was placed on the glass plate. Gel Bond is specially prepared plastic film and agarose will adhere to its hydrophobic side only. A rubber band (gasket) of about 15 x 22 cm with its inner edges cut to leave



a 1 mm thick edge was fitted on the plate with the Gel Bond. Another clean dry glass plate was placed onto the Gel Bond. The Gel Bond was held firmly between the glass plates by strong clips. Now the plate could stand vertically using clamps. Prepared agarose was introduced into Gel Bond using a syringe fitted with a needle between the plates. Several agarose gels were prepared in the same way and left to polymerise then later transferred to the refrigerator.

#### Preparation of buffers

Stock electrode and development buffers were prepared according to the type of enzyme to be analysed. The weights of ingredients required per litre were worked out from their Molecular weights and the molarities given for each buffer. The molecular weight (mwt) of most buffer ingredients is given on the label on the bottle and if the chemical contains water of crystallisation this will be included in the molecular weight. Therefore the strength of a chemical solution can be expressed in percentages or in terms of its molarity (M). Molarity expresses solution strength in terms of Molecular weight. Thus a one molar solution (1.0 M) can be defined as the molecular weight in grams dissolved and made up to one litre with distilled water.

Distilled water was used for making up all solutions. The calculated ingredients were weighed and mixed together until dissolved in about 750 - 900 ml of distilled water in a beaker using a magnetic stirrer. Finally solutions were made up to 1000 ml and mixed thoroughly. The pH of each solution prepared was measured and set to the stipulated level e.g.

- (i) 0.245 M  $\text{NaH}_2\text{PO}_4$ /0.15 M citric acid, adjusted to pH 5.9 with NaOH.
- (ii) 0.1 M Tris/0.1 M maleate/0.01 M  $\text{Na}_2\text{EDTA}$ /0.01 M  $\text{MgCl}_2$  adjusted to pH 7.4 with NaOH;
- (iii) 0.1 M Tris/0.1 M  $\text{NaH}_2\text{PO}_4$  pH 7.6; and
- (iv) 0.039 M  $\text{NaH}_2\text{PO}_4$ +0.061 M Na  $\text{HPO}_4$  pH 8.0

Termite extracts which were kept in form of 10 beads were introduced on marked positions on the gels, using a 5 mm Whatman paper or a piece of thread. These applicators contained known termite samples and all extracts from different nest colonies were aligned on gels which were mounted on the Flat Bed apparatus. In the case of starch gels the electrode buffer was kept in the anode (+) and cathode (-) reservoir tanks on each side of the Flat Bed. The soaked wick from either side was placed over the gel covering about 1 cm from the edge. The gel was then covered with glass plate followed by the Flat Bed apparatus cover which contains electric terminals.

When using agarose and polyacrylamide gels stripwicks were soaked in both acidic and basic solutions and dried before placing them on the Flat Bed apparatus. For example if 0.01M  $H_2SO_4$  and 1M NaOH were used, the soaked wick from the former solutions was aligned across the gel on the (+) side, while the wick soaked in the latter was placed on the (-) side. The machine was then switched on and the voltage, volthour, and time were set. After this the experiment was started. Applicators were removed after 45 minutes to 1 hour and the experiment was allowed to run until the volthour integrator registered 1500vh.

#### Staining procedure

Staining for specific enzymes was carried out using recipes and conditions given by Harris et al. 1977. Stain solution was poured onto the gel in a staining dish. After a few minutes the gel was transferred into the incubator at  $37.5^{\circ}C$  for about 15 minutes to 1 hour until bands became reasonably clear.

General protein was stained using Coomassie Blue R-250 (or Page Blue 83) stain. After completion of the run the gel was placed in a fixative solution (5% sulphosalicylic acid plus 10% trichloroacetic acid for 30 minutes, then removed and dipped into destaining solution. (Methanol: acetic acid: distilled water 3:1:5) for 30 minutes. The gel was then removed and spread on a flat bench and gently covered with blotting paper. A glass plate was placed on top followed by a two kilogramme weight to help uniform spread of weight hence uniform blotting on the gel. When completely dried, the gel was dipped into a staining solution (0.2% Coomassie Blue R-250 or page blue) for 10 minutes. Finally the gel was removed and dipped into a series of destaining solutions until the protein bands became clear and visible.

## R E S U L T S

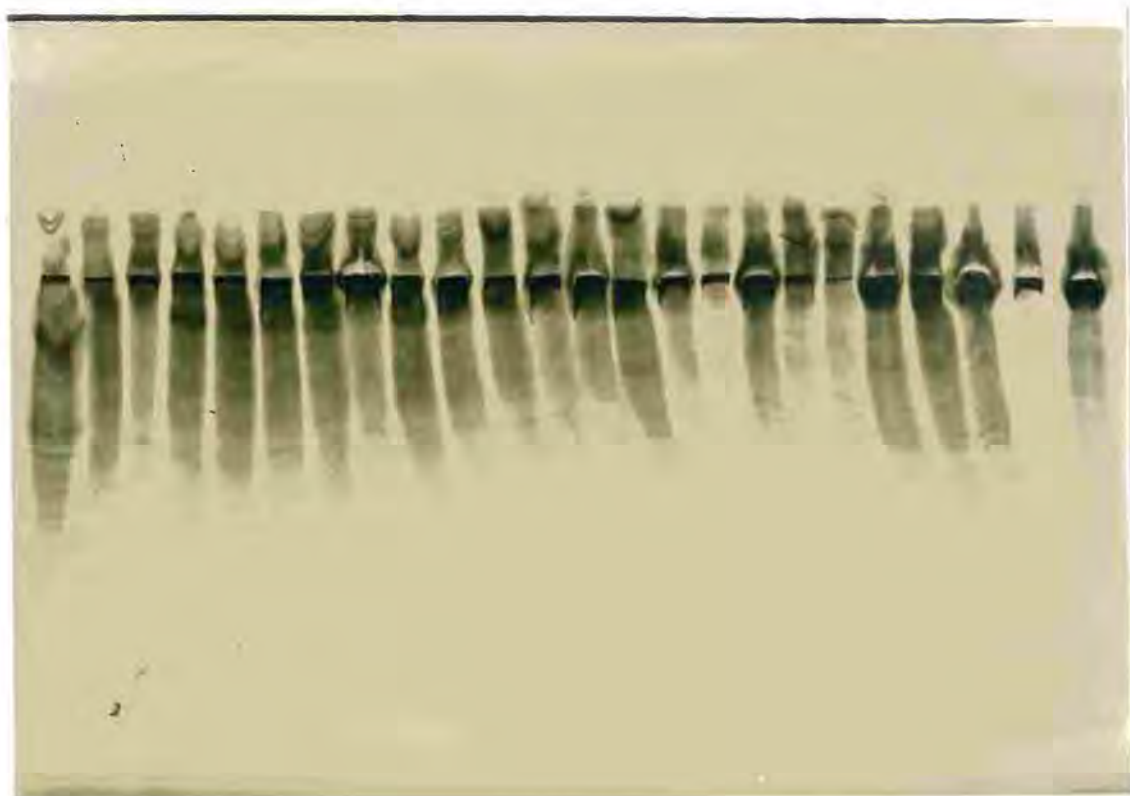
An attempt was made to investigate the possibility of using biochemical techniques (Isoenzyme analysis) to separate closely related species of Odontotermes. Specific detection of enzymes following electrophores on 10% starch gel, agarose gel and polyacrylamide gel of the twenty four groups of Odontotermes did not show good results. In general terms there were no enzymic differences revealed by these techniques. The gels showed unclear pattern of isoenzymes and protein bands.



However, general protein results (plates A and B) revealed weak bands indicating low protein content in soldier termite extracts. Nevertheless the technique looks a promising tool for species identification if causes for unclear bands are sort out and methods improved. Five glycolytic isoenzymes were used for the identification purposes, these were glucose -6-phosphate dehydrogenase (G-6-PDH), glucose phosphate isomerase (GPI), glycerol-3-phosphate dehydrogenase (GPD), malate dehydrogenase (MDH) and phosphoglucomutase (PGM). Plates C and D shows some of the results obtained on isoelectrofocusing pattern of PGM and GPI respectively. Similar or poor results were obtained from other glycolytic Isoenzymes tested.

Plate E contains eleven samples which belong to a mixture of species from various insects groups. Out of these, four are of different insect orders (see key plate E). The reason for subjecting other insects to similar extraction and running conditions with Odontotermes was to compare the results. This also could help in assessing the suitability of the technique used. The results, indicated that soldier head extract revealed some protein bands while the other body parts including the worker extract of Odontotermes showed very little in terms of protein bands. There were no alates available to compare with. On the other hand tsetse, mosquito, army worm larvae and cotton stainers extracts revealed clear protein bands. These results suggests that the extraction, running and staining methods were perfect. Major soldiers of Macrotermes also showed some protein bands.

Plate A. Separation of various proteins using agarose IEF gel run in 1500 vh, 1500 v, 150mA and 10w.



Key: shows the arrangement of samples on gel: from left to right.

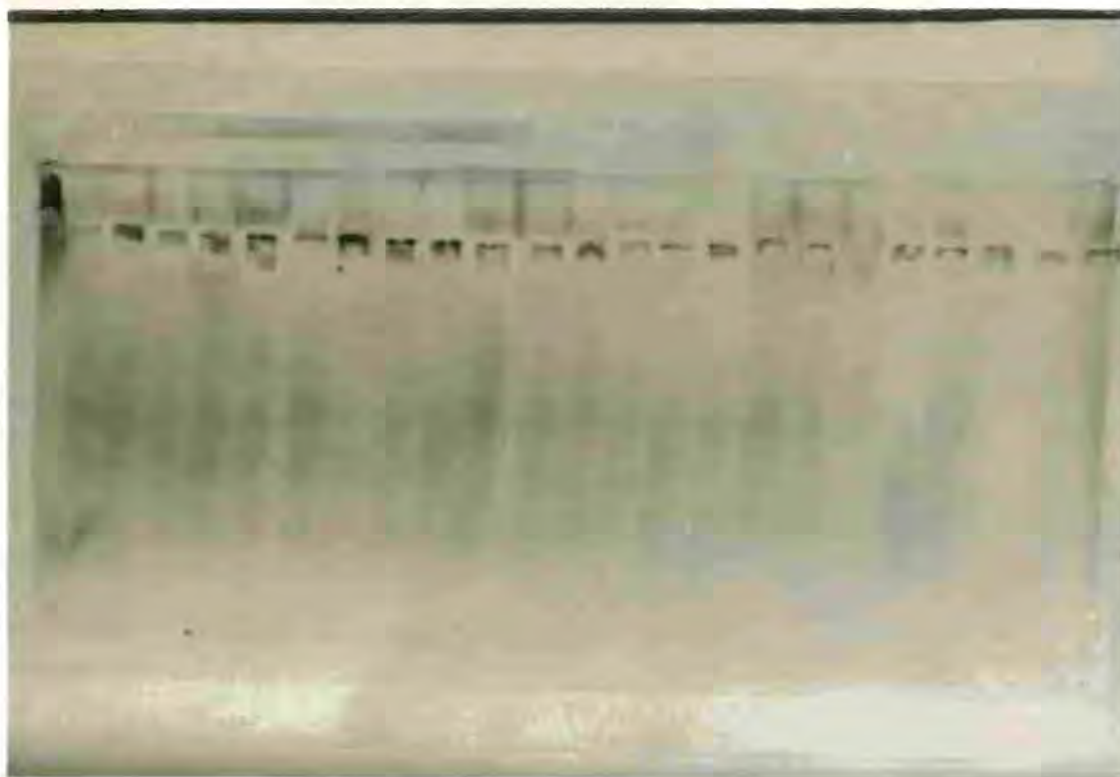
1.	Ruaraka nest	3	13.	Dagoretti nest	1
2.	Langata nest	2	14.	Kisii nest	5
3.	Kajiado nest	1	15.	Ruaraka nest	2
4.	Kajiado nest	2	16.	Ruaraka nest	5
5.	Ruaraka nest	4	17.	Langata nest	1
6.	Kisii nest	4	18.	Langata nest	3
7.	Ruaraka nest	1	19.	Langata nest	4
8.	Kerich nest	1	20.	Kisii nest	2
9.	Kisii nest	3	21.	Kisii nest	1
10.	Kisii nest	6	22.	Kajiado nest	3
11.	Kisii nest	7	23.	Kajiado nest	4
12.	Meru nest	1	24.	Muguga nest	1

Plate B. separation of various proteins using polyacrylamide IEF gel run 1500 vh, 1500 V 150mA and 30w.

Key: shows the arrangement of samples on the gels: from left to right.

1.	Ruaraka nest	3	14	Kisii nest	5
2.	Langata nest	2	15.	Ruaraka nest	2
3.	Kajiado nest	1	16.	Ruarka nest	5
4.	Kajiado nest	2	17.	Langata nest	1
5.	Ruaraka nest	4	18.	Langata nest	3
6.	Kisii nest	4	19.	Langata nest	4
7.	Ruaraka nest	1	20.	Kisii nest	2
8.	Kericho nest	1	21.	Kisii nest	1
9.	Kisii nest	3	22.	Kajiado nest	3
10.	Kisii nest	6	23.	Kajiado nest	4
11.	Kisii nest	7	24.	Muguga nest	1
12.	Meru nest	1	25	Macrotermes soldier for Ruaraka	
13.	Dagoretti nest	1			

Plate C. Separation of isoenzymes of phosphoglucomutase by agarose IEF gel run in 150 vh, 1500 V 150mA and 30w.



Key: Shows the arrangement of samples on the gels: from left to right.

1.	Ruaraka nest	3	13.	Dagoretti	1
2.	Langata nest	2	14.	Kisii nest	5
3.	Kajiado nest	1	15.	Ruaraka nest	2
4.	Kajiado nest	2	16.	Ruaraka nest	5
5.	Ruaraka nest	4	17.	Langata nest	1
6.	Kisii nest	4	18.	Langata nest	3
7.	Ruaraka nest	1	19.	Langata nest	4
8.	Kericho nest	1	20.	Kisii nest	2
9.	Kisii nest	3	21.	Kisii nest	1
10.	Kisii nest	6	22.	Kajiado nest	3
11.	Kisii nest	7	23.	Kajiado nest	4
12.	Meru nest	1	24.	Muguga nest	1



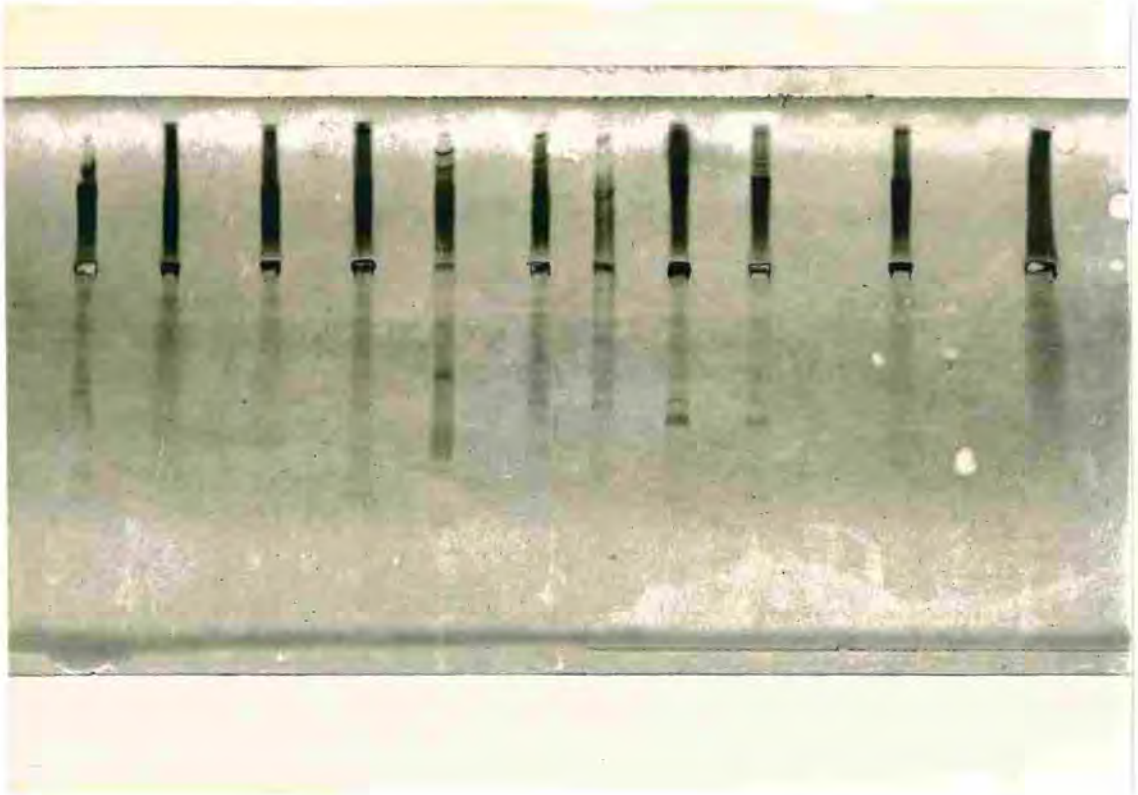
Plate D. Separation of isoenzymes of Glucose phosphate isomerase by agarose IEF gel run in 1500 v, 1500 V 150mA and 10w.



Key: shows the arrangement of sample on teh gels: from left to right.

1.	Ruaraka nest	3	13.	Dagoretti nest	1
2.	Langata nest	2	14.	Kisii nest	5
3.	Kajiado nest	1	15.	Ruaraka nest	2
4.	Kajiado nest	2	16.	Ruaraka nest	5
5.	Ruaraka nest	4	17.	Langata nest	1
6.	Kisii nest	4	18.	Langata nest	3
7.	Ruaraka nest	1	19.	Langata nest	4
8.	Kericho nest	1	20.	Kisii nest	2
9.	Kisii nest	3	21.	Kisii nest	1
10.	Kisii nest	6	22.	Kajiado nest	3
11.	Kisii nest	7	23.	Kajiado nest	4
12.	Meru nest	1	24.	Muguga nest	4

Plate E. Separation of various proteins using polyacrylamide IEF gel run in 1500 vh, 2,500 v, 150 mA and 30w.



Key: Sample extracts from left to right:

1. Soldier heads of Odontotermes species
2. Soldier thorax and abdomen of Odontotermes species
3. Complete soldiers of Odontotermes
4. Complete worker of Odontotermes
5. Complete tsetse
6. Mosquito
7. Army worm larvae
8. Cotton stainer
9. Macrotermes major soldier
10. Macrotermes minor soldier
11. Odontotermes

1.3

## DISCUSSION

Commenting on the results, it is possible that Odontotermes electrophoresis requires an improved quality on handling and extraction techniques. It is peculiar why soldier abdomen and other parts excluding head did show very weak bands. Possibly there are protein inhibitors in the abdominal extracts of Odontotermes. The defensive secretion is stored in abdominal sacklike reservoirs of the salivary glands which are connected to the mouth cavity (wood et al. 1975). Probably defense secretion interfered with the enzyme activity in the extract hence the electrophoretic mobility. Some species of Odontotermes especially those in the "badius" and 'tanganicus' groups use a quinone - protein mixture (Coles, 1980; Coles and Howse, 1982; Howse, 1984) as a defense secretion, which rapidly tans becoming glutinous (wood et al. 1975). Whether the quinone - protein mixture has an effect on electrophoretic mobility of isoenzymes is just a matter of speculation. However, more detailed research needs to be carried out to determine the possibility of using biochemical techniques on Odontotermes species.