Some Data on Geomorphology of Termite Mounds in Tropical Africa

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Some Data on Geomorphology of Termite Mounds in Tropical Africa

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Abstract In order to make geomorphological assessment of termite activity in the tropical land, total volume of termite mounds per unit area has been estimated through the procedure of morphological typology, simple measurement of dimensions, and observation of areal frequency, of termite mounds in selected locations in several countries of Africa. Although different with species and locations, the value is, except extreme cases, between 1,000 and 10,000 m^3/km^2. Volume of earth accumulated in mounds may be around the half of the above value. In addition to the volumetric data, inequality in mound distribution has been investigated in relation to landsurface condition in topographic or detailed scale. Both intensive observation of life history of various types of mounds on selected sites in different environments and extensive survey of mound distribution over the tropical zone are necessary for further study of geomorphology of termite mounds.

Key words: biogenic geomorphology, termite mounds, total volume, topographic location, tropical Africa.

1 Introduction

Geomorphological significance of termite activity in tropical areas has been stressed by many authors and it has been recently assessed more comprehensively by, for instance, Goudie (1988) and Tamura (1991). Tamura (1991) indicates that there is a similarity between termite and man in terms of work against gravity but landforming processes made by termite should be first considered in the same category with some other natural processes of earth-surface material transfer. Volume of individual termite mound and areal distribution of mounds in relation to various environmental conditions provide basic data for the geomorphic assessment of termites' work. This short note presents the results of simple observation of volume and areal occurrence of termite mounds, as well as preliminary consideration of earth-surface material transfer by termite and landform condition for termite mound development. The observation has been made by the authors in field research works of different purposes in several areas of tropical Africa.

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2 Procedure

Tamura (1991) classifies termite mounds into the following three form types: (a) small cone type, usually lower than 1 or 2 m, (b) tower type, consisting of a lower dome or cone one to several meters high and an upper pillar several meters high, and (c) big dome type, often exceeding 10 m in diameter of its base (Fig. 1). Although the typology lacks a genetic background, it is useful for simple estimation of volume of a termite mound on basis of observed dimensions. Using d and h for mean basal diameter and height of a mound, respectively, V, that designates volume of the mound, is estimated as:

$V=\pi d^2 h/12$ for a (a)-type mound,

$V=\pi d_1^2 h_1/(8\sim 12)+\pi d_2^2 h_2/4$ for a (b)-type mound,

when d_1 is mean basal diameter of lower dome or cone,

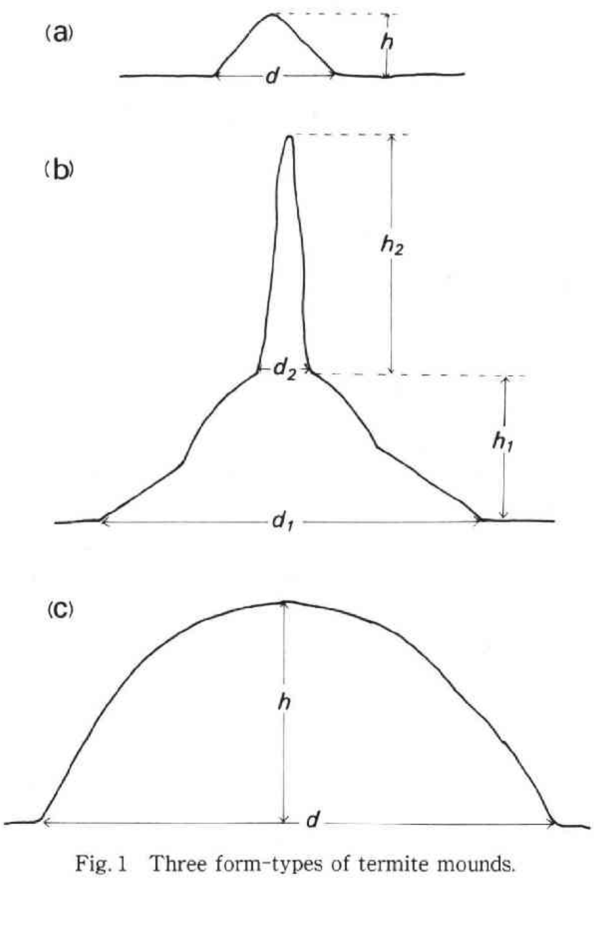

Fig. 1 Three form-types of termite mounds.

h_1 is height of lower dome or cone,
d_2 is mean diameter of upper pillar,
h_2 is height of upper pillar,

$V = \pi d^2 h/(6\sim10)$ for a (c)-type mound.

Areal frequency or distribution density of termite mounds, which is designated as f, is obtained by measurement using quadrats or is estimated on ground of distance between mounds. Total volume of termite mounds per unit area is represented by $V \times f$. Total volume of earth composing mounds in an area can be derived from the value in application of void ratio of termite mounds, which is variable and is not easily measurable. This report, referring to several publications, *e.g.*, Williams (1968) and Lee and Wood (1971), applies the average or tentative void ratio 0.5 to further preliminary discussion of earth movement concerned with mound building.

In addition to measured dimensions and estimated volumes of termite mounds, environmental conditions of respective observation sites are mentioned. Information on landform, vegetation, and soil is obtained from mostly on-site observation. Climatic condition is estimated with reference to Walter and Lieth (1960).

3 Results

3.1. Volume and rate

Ten typical examples of termite mounds assemblages have been selected among the authors' observation and total volume of mounds in each selected location has been estimated in the above-mentioned procedure. The results, as well as information on the environment of respective mound-occurring locations, are shown in Table 1. Location map is provided in Fig. 2.

Volume of individual mound varies widely. While the maximum volume estimated reaches 500 m^3, the smallest mound observed has volume of only 0.005 m^3, and many smaller mounds escape from observation. Areal frequency of mounds has a tendency to be high in smaller mounds of (a)-type, in contrast with the trend of low frequency in bigger mounds of (b)- or (c)-type, mostly of *Macrotermes* sp. Thereby total volume of mounds per unit area is, in most cases, within the not so wide range from 1,000 to 10,000 m^3/km^2. Total volume exceeding 20,000 m^3/km^2 seems to occur in rather extreme cases.

Applying the average or tentative void ratio 0.5, the above values provide that total volume of earth, ranging from about 500 to 5,000 m^3/km^2, is accumulated in termite mounds. The range covers the previously reported value (*e.g.*, Nye 1955 ; Lee and Wood, 1971 ; Lepage 1984).

For the assessment of termite activity as a geomorphic agent, information on not

Table 1 Location, environment, dimension

1)	Location	Latitude Longitude Altitude	Annual precip. Length of drought period 2)	Land form	Vegetation	Soil texture Lithology
1	S of Meiganga Adamaoua Cameroon	06° 28′N 14° 15′E 950 m	1400 mm 4 5 mths	Footslope of a small rounded hill	Wooded savanna	Orange loam (lateritic hor.) Granitic rock
2	E of Okene Central Nigeria	07° 30′N 06° 24′E 300 m	1300 mm 5 mths	Footslope of a rock dome	Wooded savanna	Reddish brown loam Granitic rock
3	E of Shangani SW Zimbabwe	19° 46′S 29° 25′E 1400 m	700 mm 7 mths	Very gently undulating	Pasture (ranch)	Dull orange clay loam Precamb. basem.
4	N of Sakania S Shaba Zaire	12° 15′S 28° 30′E 1200 m	1300 mm 6 mths	Gently undulating	Woodland	Orange clay loam Precambrian sandstone?
5	SW of Abuja Central Nigeria	08° 38′N 06° 55′E 130 m	1200 mm 5 mths	Almost flat (Low Plateau)	Farm	Reddish brown loam (unknown)
6	Kabompo NW Zambia	13° 37′N 24° 12′E 1070 m	1100 mm 5 6 mths	Almost flat (Sand Plateau)	Bush (in settlement)	Reddish sandy loam Unconsol. sands
7	W of Kabompo NW Zambia	13° 38′S 24° 09′E 1060 m	1100 mm 5 6 mths	Almost flat (River terrace & floodplain)	Woodland, farm and grassland	Yellowish loam and grey white clay loam Unconsol. sands
8	S of Masvingo SE Zimbabwe	20° 15′S 30° 54′E 1080 m	600 mm 7 mths	Undulating with hillocks	Farm (just cleared from woodland)	Reddish brown clay loam Granite
9	Ngaoundere Adamaoua Cameroon	07° 20′N 13° 36′E 1100 m	1500 mm 5 mths	Gently undulating	Bush (grazed)	Reddish brown clay loam Granite
10	S of Mzimba N Malawi	11° 58′S 33° 37′E 1400 m	1000 mm 6 mths	Rolling	Woodland	Reddish brown loam Precamb. basem.

Notes: 1) Location numbers are common to Fig. 2.
2) Based on or estimated from Walter and Lieth (1960).
3) According to the classification explained in the text and Fig. 1.
4) See the text and Fig. 1 for definition of respective dimensions.
5) Observer T: Tamura, S: Sakaida and Shimada.
6) According to T. Matsumoto, Univ. of Tokyo.
7) Having a characteristic umbrella (see Photos 1 and 2).
8) A little different from tower type (see Photo 6).
9) Some mounds were completely destroyed for earth material collection.

and estimated volume of termite mounds observed.

Species of termite	Form type of mound 3)	Dimension d or d_1/d_2 h or h_1/h_2 (m) 4)	Estimated volume of a mound V (m^3)	Average of areal frequency f ($1/km^2$)	Total volume per area (m^3/km^2)	Observation 5)	Photo No.
Cuvitermes sp. 6)	(a)′ 7)	0.15–0.2 0.3–0.4	0.005–0.01	$1-2\times10^5$	800–1,500	T Dec, 80	1,2
(unknown)	(a)	0.2–0.7 0.1–0.3	0.03–0.4	1.4×10^4 ($13/900\ m^2$)	300	S Aug, 90	3
(unknown)	(a)	0.5–1 0.3–1	0.03–0.4	$3-4\times10^4$	2,000–4,000	T Oct, 90	4
Macrotermes (?) (abandoned)	(b)				3,000–20,000	T Jul. 87	5
(unknown)	(b)′ 8)	3 5–7	8–12	$5-6\times10^2$	5,000–7,000	S Aug, 90	6
Macrotermes sp.	(b)	5/0.7	15 2.5/4	(no data)		T Jul, 87	7
Macrotermes sp.	(b)	1–4/0.1–0.3 1–1.5/2–3	0.3–10	430 ($129/0.3\ km^2$)	500–1,200	T Aug. 87	8
	(c)	5–15 3–5	30–400				9
Macrotermes (?) (abandoned and partly destroyed)	(c)	4–5 3–4	20–50	$0.3-1\times10^3$	5,000–25,000	T Oct. 90	10
Macrotermes (?) (abandoned and half destroyed)	(c)	5–8 2–5	20–100	100 (?) 9)	2,000–10,000 (?)	T Dec, 80	11
Macrotermes (?) (abandoned and partly destroyed)	(c)	15 5	500	(no data)		T Aug. 89	12

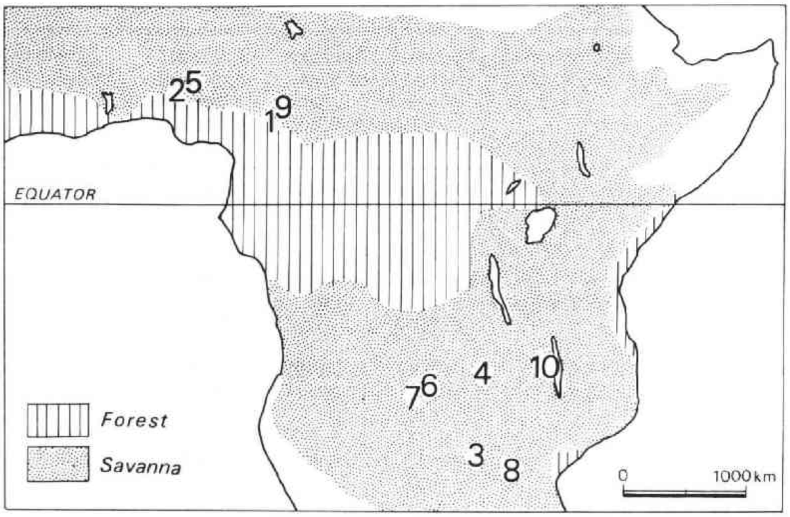

Fig. 2 Location map.
Location numbers are common to Table 1.

only the total volume but also the rate of accumulation and release of earth material in and from mounds is necessary. The rate can be derived from the duration of construction and destruction of the mounds of known volume. However, previous reports on the above values vary very widely as reviewed by Tamura (1991). Moreover, Pullan (1979) presents a very long range of compound processes, which includes construction, destruction and reconstruction, for the development of huge dome-shaped termite hills which he discriminates from other type termite mounds. If such processes take place commonly volumetric information on termite mounds may become of no use for estimation of the rate of termite-induced earth material transfer.

Although Tamura (1991) presents the estimated rate of surface sediments formation from regolith by termites as 10^0 to 10^2 $m^3/km^2/y$, which is roughly equivalent to the natural denudation rate in tropical interfluves except mountains as summarized by Young (1969), more systematic observation on life history of not only termite colony but also termite mound is necessary for application of basic data as summarized in Table 1 for further discussion of termite-induced earth-surface material transfer.

3.2. Topographic location

Table 1 presents the information on topographic-scale landform condition of the sites where termite mounds occur. More detailed-scale observation elucidates that mounds tend to avoid the location where frequent and rapid groundsurface disturbance takes place in rainy season, such as lower sideslopes, bottomlands, dambo centers and temporal channels in floodplain, where frequent wash, muddy condition and/or pro-

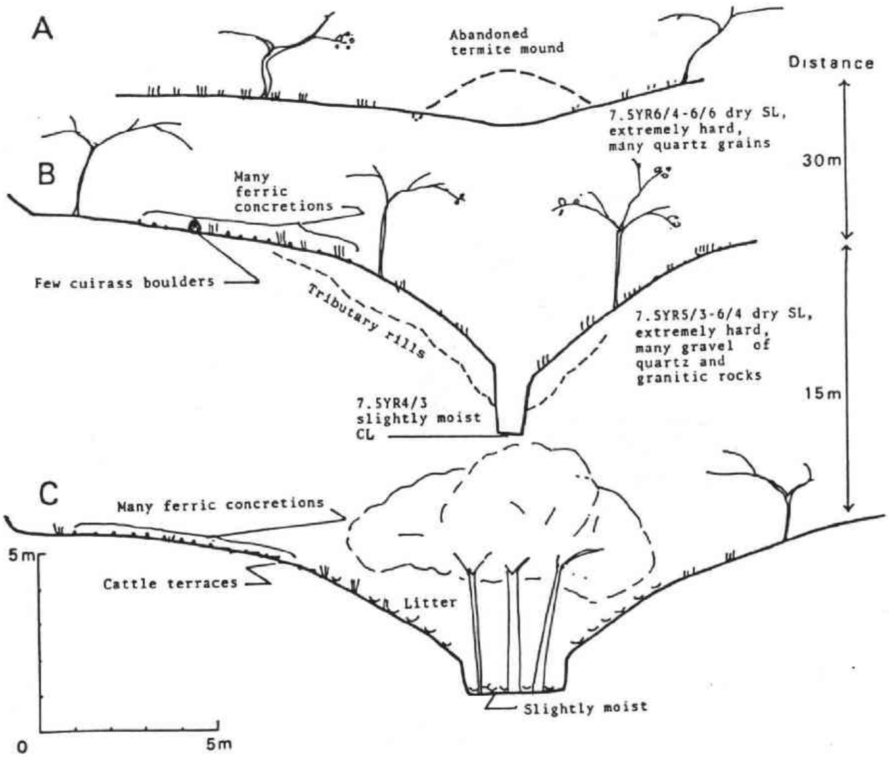

Fig. 3 Landforms and termite mounds near Belel Dibi, southeast of Ngaoundere, Cameroon (Tamura 1986).
Soil color is represented by the Munsell system. Texture is abbreviated as follows: C; clay or clayey, L; loam(y), Si; silt(y).

longed submergence take place.

Fig. 3 illustrates occurrence of big (c)-type termite mounds, although abandoned, in a high granite plateau in Cameroon, between Locs. 1 and 9 in Table 1 and Fig. 2. Location of mounds is restricted on gently convex upper slopes and shallow valley-head slopes. Unstable steep valley sides and almost permanently wet valley bottoms are free from occupation by big mounds.

Fig. 4 is an example of map depicting the detailed-scale land condition of termite mounds location. It depicts Loc. 7 in Table 1 and Fig. 2, situated in a river valley by which the Kalahari Sands plateau is dissected in Northwestern Zambia. Most mounds distributed in the area are of (b)-type 3 to 4 m high (Photo 8) associated with some (c)-type ones 5 to 15 m across (Photo 9). The diagram suggests that the distribution of mounds is severely controlled by soil texture and drainage conditions which closely related with landform.

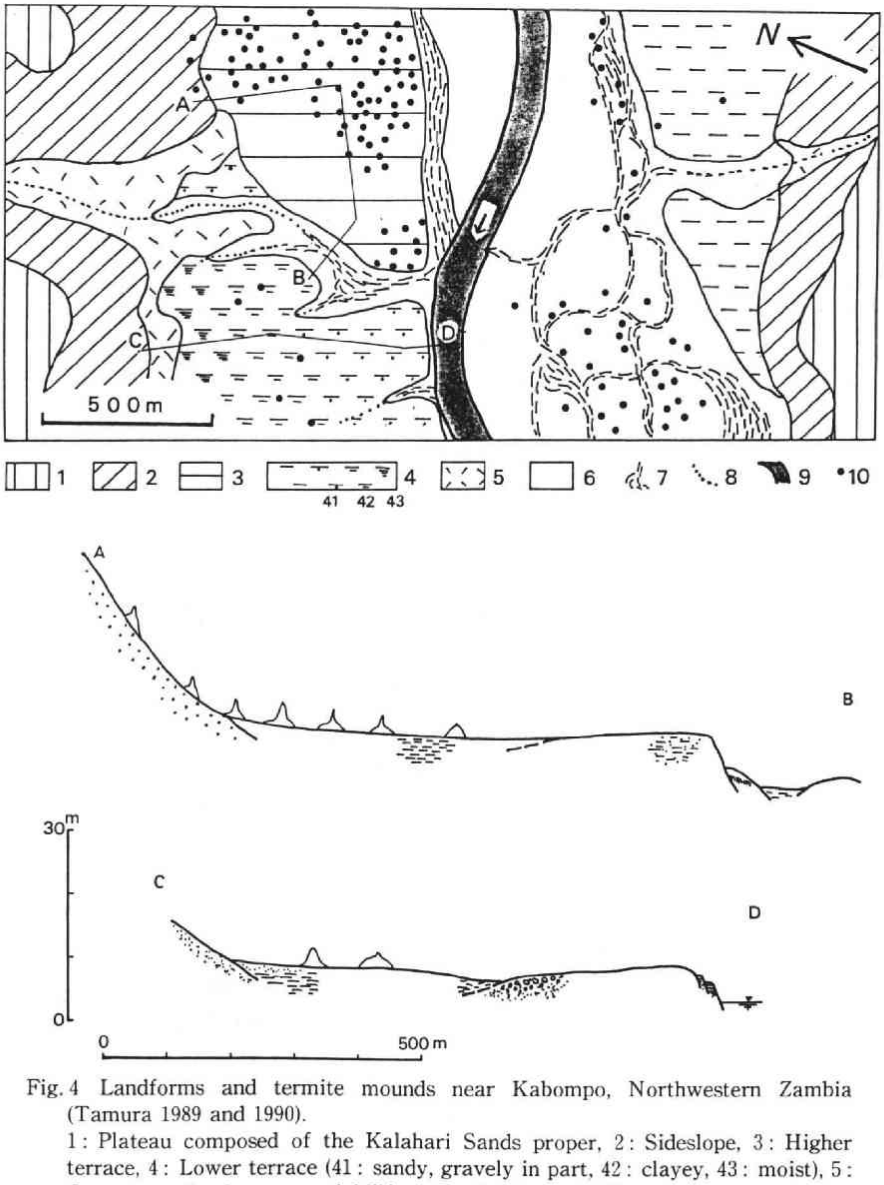

Fig. 4 Landforms and termite mounds near Kabompo, Northwestern Zambia (Tamura 1989 and 1990).

1: Plateau composed of the Kalahari Sands proper, 2: Sideslope, 3: Higher terrace, 4: Lower terrace (41: sandy, gravely in part, 42: clayey, 43: moist), 5: Concave valley-bottom and hillfoot gentle slope, 6: Natural levee, 7: Lower floodplain including the course of floodwater stream, 8: Ephemeral stream, 9: Main course of the River Kabompo, 10: Termite mound (mostly of tower- or dome-type). Mound on most part of the plateau and sideslopes may be obscured by miombo woodlands.

4 Concluding Remarks

Morphological typology, simple measurement of width and height, and observation of areal frequency or distribution density of termite mounds in about ten locations in Tropical Africa leads to the estimation of total volume of mounds per unit area as 1,000 to 10,000 m^3/km^2, and about the half of it is earth material accumulated in the mounds. The rate of earth material transfer by termite can be derived from the above value when information on the rate of construction and destruction of mounds is provided by systematic observation of life history of termite mounds.

However, basic data for the above consideration have been obtained from the areas occupied rather densely by termite mounds, and extensive areas with very few or no mounds are intermingled with densely occupied areas. Study of inequality in mound distribution and factors controlling it is necessary for the more comprehensive understanding of termite activity as a geomorphic agent in tropical lands.

As a step in such study, landform condition of termite mounds occurring sites is investigated, and it is remarked that unstable or sensitive groundsurface, such as steep valley-sides, perpetually wet valley bottoms, seasonally muddy and/or submerged dambo centers, and temporal channels in floodplain, escapes from the occupation by termite mounds.

Finally it is mentioned that intensive observation of construction, maintenance and destruction of mounds of various species of termites in selected sites which represent different environments, as well as extensive survey of mounds distribution over the tropical zone, is of the most important for further study of termite activity from geomorphological viewpoint.

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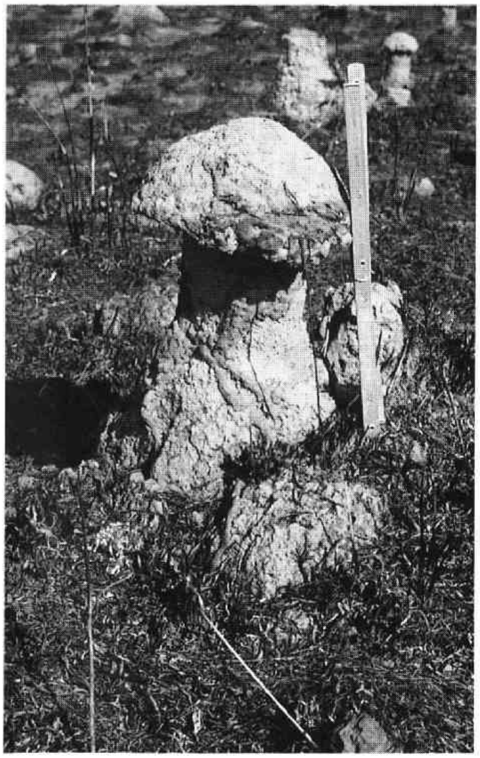

Photos 1 and 2 Mounds of *Cuvitermes* sp. in Loc. 1, Nandeke, south of Meiganga, Adamaoua, Cameroon. (Photo by T. Tamura, Dec., 1980)

Photo 3 A mound of unknown termite in Loc. 2, Ebiya, east of Okene, Central Nigeria. (Photo by K. Sakaida, Aug., 1990)

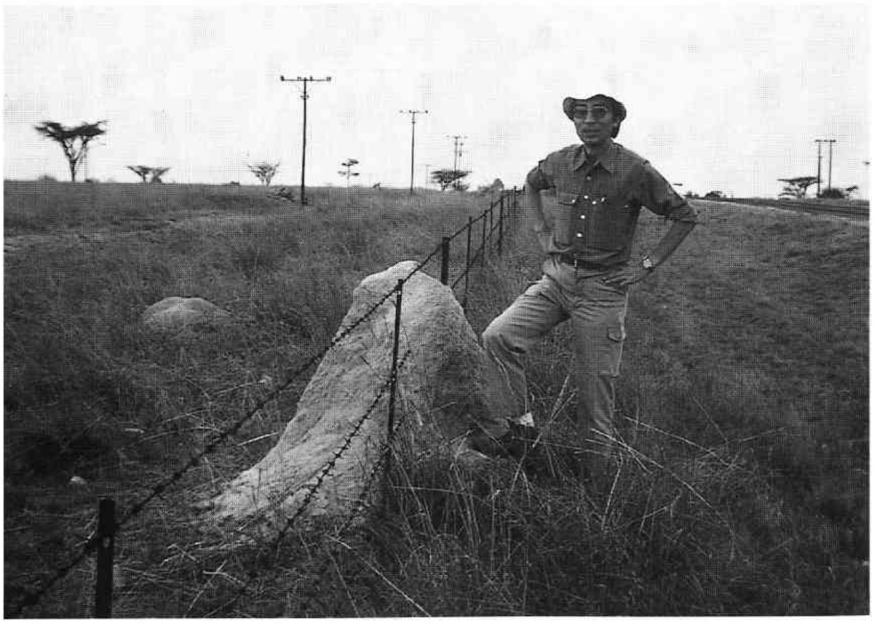

Photo 4 Growing mounds in Loc. 3, east of Shangani, Southwestern Zimbabwe. (Photo by K. Iwasaki, Oct., 1990)

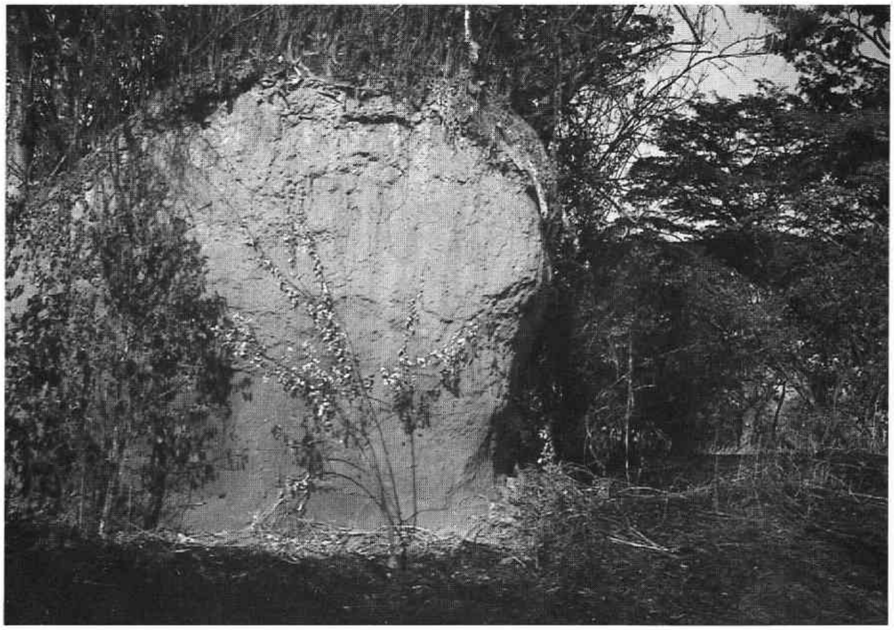

Photo 5 A big mound of probably *Macrotermes* sp. in Loc. 4, north of Sakania, Shaba, Zaire. A pillar had collapsed. (Photo by K. Takeuchi, July, 1987)

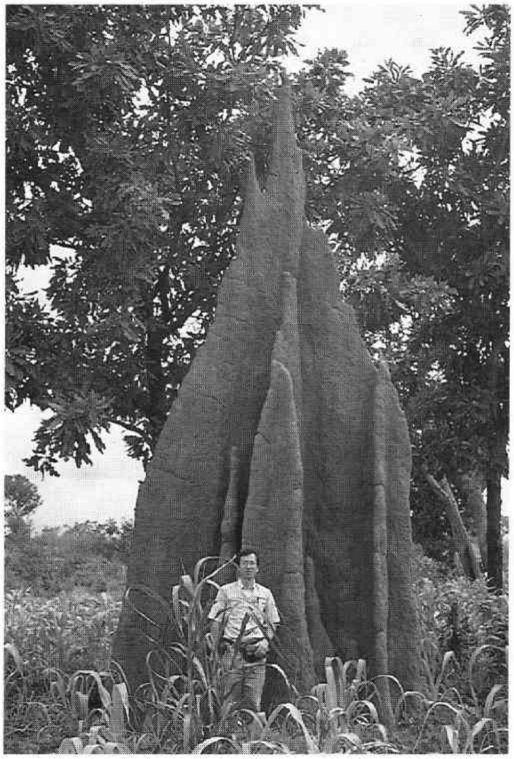

Photo 6 A big mound in Loc. 5, southwest of Abuja, Central Nigeria. (Photo by S. Shimada, Aug., 1990)

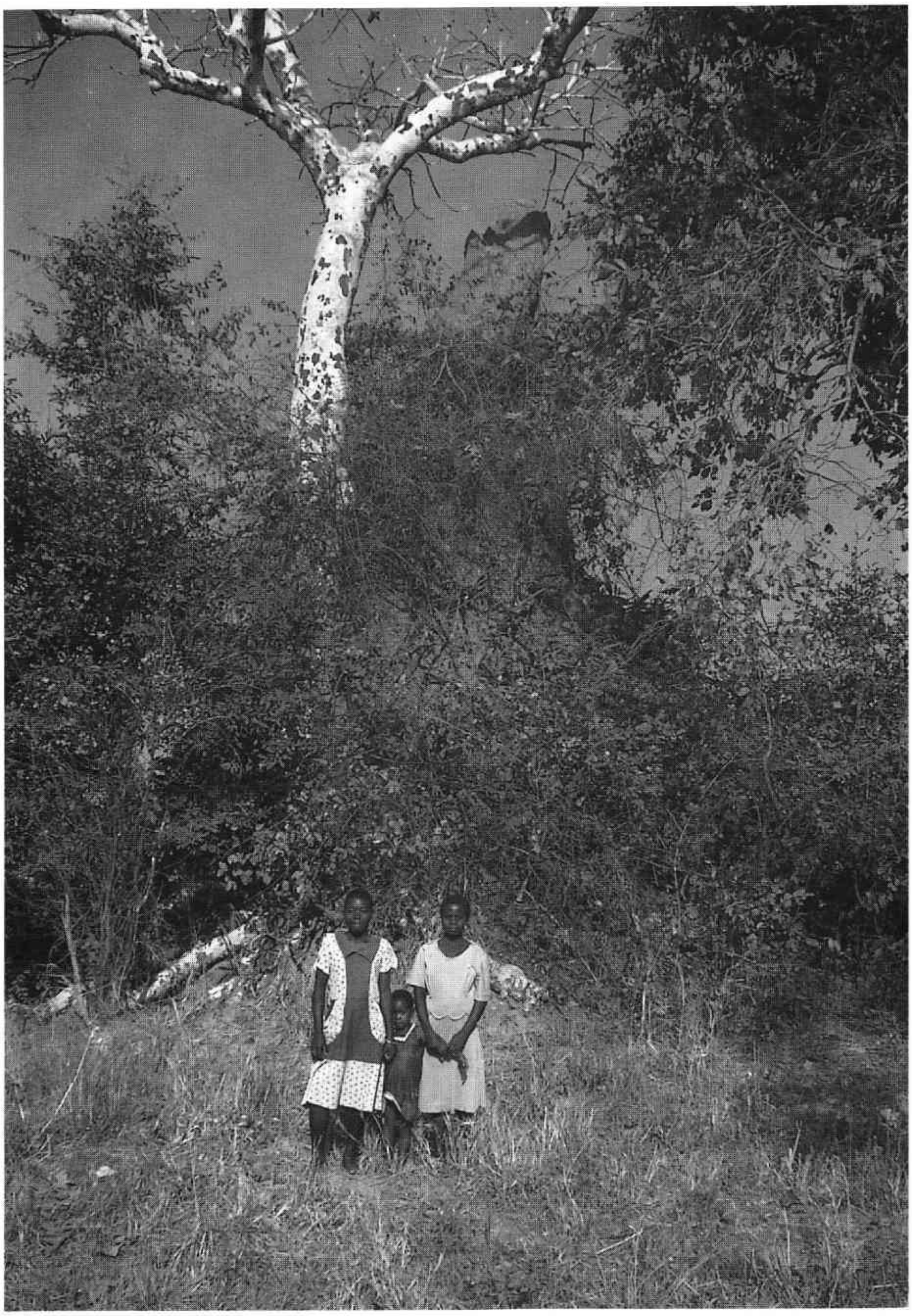

Photo 7 A big mound of *Macrotermes* sp. in Loc. 6, on the Sand Plateau at Kabompo, Northwestern Zambia. (Photo by T. Tamura, July, 1987)

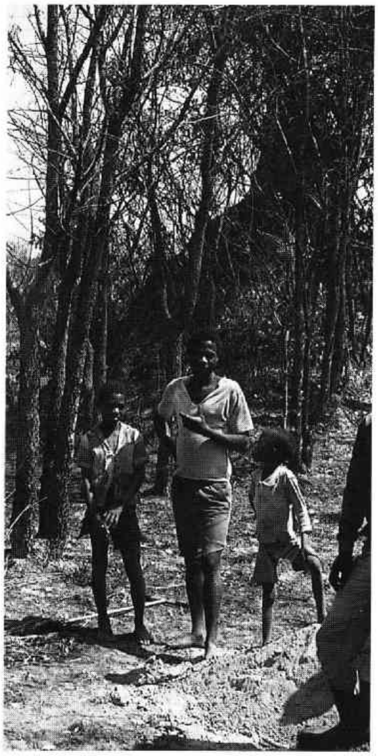

Photo 8 A mound on the higher terrace in Loc. 7, west of Kabompo, Northwestern Zambia. (Photo by T. Tamura, Aug., 1987)

Photo 9 A big dome-type mound on the lower terrace in Loc. 7. (Photo by T. Tamura, Aug., 1987)

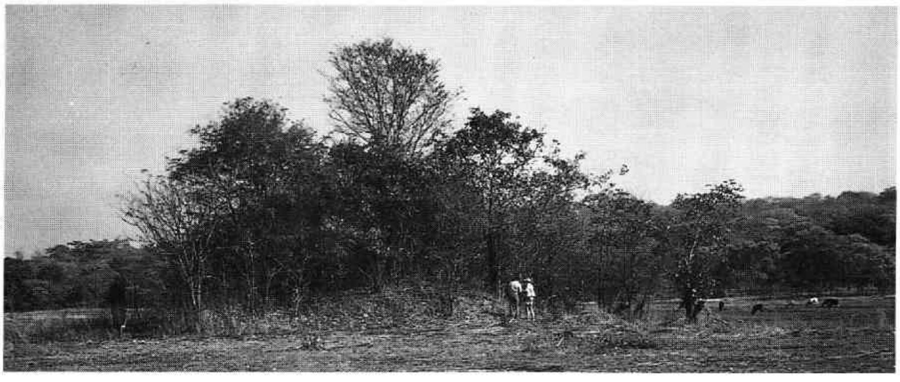

Photo 10 A half-destroyed mound of probably *Macrotermes* sp. in Loc., 8, south of Masvingo, Southeastern Zimbabwe. (Photo by T. Tamura, Oct., 1990)

Photo 11 A half-destroyed mound of probably *Macrotermes* sp. in Loc. 9, Ngaoundere, Adamaoua, Cameroon. (Photo by T. Tamura, Dec., 1980)

Photo 12 A big mound of probably *Macrotermes* sp. in Loc. 10, Mzimba, Northern Malawi. (Photo by T. Tamura, Aug., 1989)