

**CASTE POLYMORPHISM IN FIELD COLONY OF *ODONTOTERMES*
REDEMANNI (WASMANN)**

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Abstract: Total population of the nest opened on 20th December, 1986 consisted of 99033 individuals. The soldier to worker ratio in the nest population was 1:8 and workers constituted 6% and 48% of the total population, respectively.

Two types of workers minor and major, were found in the nest. The major worker passes through five instars, first three larval and the last two worker instars. Minor worker also develops from 3rd instar larva and after another moult changes into minor worker.

Origin of the pre-soldier takes place from 3rd larval instar and this pre-soldier after another six moults develops into the soldier caste. Neither alates nor developmental stages leading to alates were found in the nest opened in December *i.e.*, after the swarming season was over.

Key words: Caste polymorphism, field colony, termite.

INTRODUCTION

O *odontotermes redemanni* whose developmental pathways are discussed in the present report was first of all described by Wasmann in 1893 from Ceylon (now Sri Lanka). It was thought to be confined to Ceylon only. Later on it has been recorded from many localities of India by Bose (1984) who has further pointed out that *O. redemanni* and *O. obesus* cannot be easily separated and preferred to consider them two species in a group, till their taxonomic problem is solved. The present material collected from Lahore has been compared with *O. redemanni* collected by Escherich on 17th Feb. 1900 from Ceylon and was determined by Holmgren. It has also been compared with *O. redemanni* collected from Ceylon on Oct. 15, 1928 which was identified by Ahmad. The specimen whose developmental pathways are described here come more close to *O. redemanni* than to *O. obesus*.

MATERIALS AND METHODS

The material used in the present study consisted of a population of a nest of subterranean termites *O. redemanni*. The nest was opened in the month of Dec. 1986 and was dug out for an area of four m².

For caste composition soldiers were counted individually whereas number of undifferentiated population of nymph was counted by volume method as explained by Thorne (1985).

The population of the nest was preserved in 80% alcohol. The specimens were measured under Leitz stereoscopic microscope with built in magnification changer. Measurements of different instars of worker and soldier lines were taken with the aid of

calibrated ocular micrometer. Illustrations were prepared with the help of Camera Lucida wherever necessary photographs of the various developmental stages were taken under microscope.

Taxonomic terms and measurements used in the present study are as explained by Emerson (1945), Ahmad (1950) and Noirot (1985).

To trace the origin of the worker and soldier lines following characters were measured:

1. Total body length.
2. Length of head to side base of mandible.
3. Maximum width of head.
4. Length of hind tibia.

Numerical data for various characters was analyzed for mean, standard deviation, coefficient of variation, according to Sokal and Rohlf (1973).

In the tables mean is represented as X, standard deviation as S.D. and coefficient of variation is represented by C.V.

RESULTS

Caste composition of *Odontotermes redemanni*

The subterranean nest of *O. redemanni* was opened on Dec. 12, 1986, and a total of 4.0 M² area was dug out. Caste composition of the nest is given in Table I.

Soldier worker ratio in the nest population was 1:8.

Table I. Cast composition of a nest of *Odontotermes redemanni*

Caste	Number	Percentage of total
Soldier	6583(1:8)*	6%
Worker	48189	48%
Nymph	44261	44%
Total Population	99033	

*Soldier to worker ratio

(1) Description of developmental pathways of workers line

a) First instar larva-12 antennal segments

Head and body whitish, unpigmented; head round with brain area much enlarged, occupying nearly the whole of head capsule. Mandibles unpigmented, left mandible with minute indication of apical and first marginal tooth; right mandible with minute

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indication of apical and first marginal tooth. Antennae 12 segmented with second segment as long as third and fourth combined. Abdomen with two styli, tarsi 4-jointed (Table II).

Table II. Biometric analysis of different characters of first instar larva (measurements in mm)

Characters	Range (N=20)	Mean±S.D	C.V.
Total body length	1.15-1.40	1.27±0.089	7.00
Length of head to side base of mandible	0.26-0.32	0.29±0.013	4.48
Maximum width of head	0.39-0.45	0.43±0.023	5.34
Length of hind tibia	0.18-0.20	0.19±0.012	6.31

b) Second instar larva - 13 antennal segments

Head and body whitish, unpigmented, head round, brain area visible through cuticle, much enlarged, occupying nearly the whole of head capsule. Mandible whitish, unpigmented, right mandible with apical and first marginal tooth more developed than first instar nymph. Notch between first marginal and second marginal tooth slightly indicated. Left mandible with apical first and second marginal tooth well indicated, notch between first and second marginal tooth slightly indicated. Mandibular differentiation in *O. redemanni* starts much earlier than *O. gurdaspurensis*. Antennae 13 segmented, abdomen with a pair of styli, tarsi 4-jointed (Table 3).

Table III. Biometric analysis of different characters of second instar larva (measurements in mm)

Characters	Range (N=7)	Mean±S.D.	C.V.
Total body length	1.85-2.11	1.93±0.099	5.12
Head length to side base of mandible	0.36-0.46	0.39±0.030	7.69
Maximum width of head	0.56-0.64	0.60±0.027	4.5
Length of hind tibia	0.36-0.41	0.38±0.016	4.21

c) Third instar larva - 14 antennal segments

Head and body whitish, unpigmented, head round, with brain area much enlarged, occupying nearly the whole of the head capsule. Mandible unpigmented and whitish. Right mandible with apical and first marginal tooth, more developed than second instar

worker. Notch between first marginal and second marginal tooth slightly indicated. Left mandible with apical and first marginal tooth well developed, yet unpigmented. Antennae 14 - segmented, abdomen with a pair of styli, tarsi 4-jointed (Table 4).

Table IV. Biometric analysis of different characters of third instar larva (measurements in mm)

Characters	Range (N=20)	Mean±S.D.	C.V.
Total body length	1.99-2.44	2.19±0.188	5.38
Head length to side base of mandible	0.41-0.54	0.48±0.033	6.87
Maximum width of head	0.67-0.77	0.70±0.045	6.42
Length of hind tibia	0.41-0.48	0.43±0.023	5.34

d) Fourth instar worker - 15 antennal segments

Head and abdomen whitish, unpigmented. Head round, brain area visible through the cuticle much reduced. Mandible whitish, and more differentiated than third instar. Right mandible with a distinct notch between first and second marginal and third marginal tooth. Second notch between posterior margin of third marginal and molar plate slightly indicated, well differentiated teeth; tip only weakly pigmented, posterior margin of third marginal tooth in this instar separated from the molar plate, molar plate not well differentiated. Antennae 15 segmented, abdomen with a pair of styli (Table V).

Table V. Biometric analysis of different characters of fourth instar larva (measurements in mm)

Characters	Range (N=20)	Mean±S.D.	C.V.
Total body length	2.47-2.73	2.58±0.084	3.25
Head length to side base of mandible	0.45-0.61	0.54±0.043	7.96
Maximum width of head	0.74-0.80	0.76±0.019	2.50
Length of hind tibia	0.48-0.61	0.53±0.047	8.86

e) Fifth instar worker - 16 antennal segments

Head and thorax slightly darker than abdomen, weakly sclerotized, head oval narrowing posteriorly, brain not clearly visible. Mandible more darkly pigmented than fourth instar; teeth well developed. Antennae 16 segmented. Abdomen with a pair of styli (Table VI)

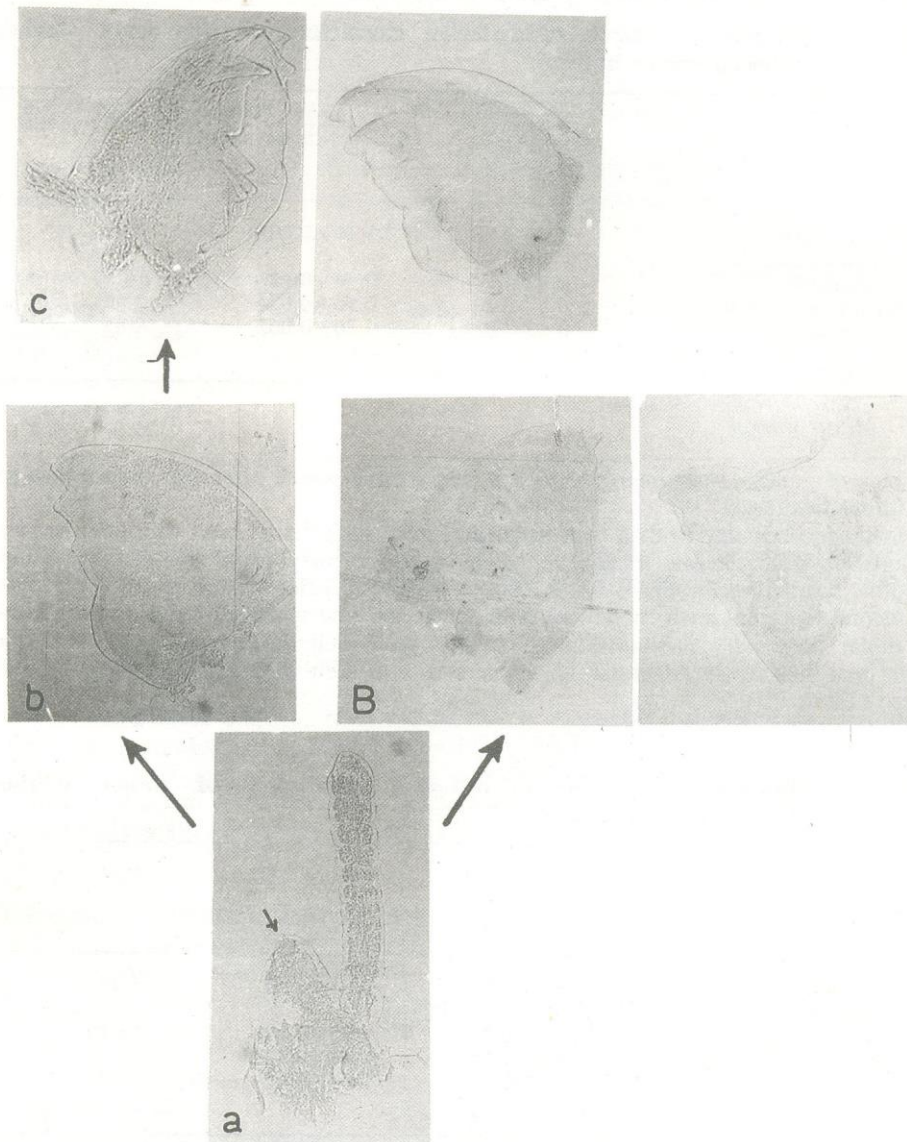
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Fig. 1. Stages of mandibular development of worker of *O. redemanni* (Wassman). a, first larval stage; b, second stage larva of minor worker; c, third stage larva of minor worker; d, third stage larva of major worker.

Table VI. Biometric analysis of different characters of fifth instar worker (measurements in mm)

Characters	Range (N=20)	Mean±S.D.	C.V.
Total body length	2.82-3.52	3.20±0.203	6.34
Head length to side base of mandible	0.49-0.94	0.76±0.126	16.57
Maximum width of head	0.77-1.23	0.96±0.024	2.50
Length of hind tibia	0.65-0.82	0.70±0.062	8.85

f) Minor worker

(This originates from one type of 3rd instar larva which after one moult changes into minor worker)

Head and body darker than fifth instar and more sclerotized; head yellowish brown, abdomen brownish yellow. Head oval narrowing posteriorly; brain area clearly visible. Mandible strongly sclerotized; left mandible with well differentiated apical tooth, first and second marginal teeth; notch between apical and first marginal tooth, second tooth and molar plate very distinct; right mandible with well developed apical, first and second marginal teeth. Antennae 17 segmented, abdomen with a pair of styli, tarsi 4-jointed (Table VII).

Table VII. Biometric analysis of different characters of minor worker (measurements in mm)

Characters	Range (N=20)	Mean±S.D.	C.V.
Total body length	3.84-4.35	4.04±0.22	5.45
Head length to side base of mandible	0.81-1.22	1.05±0.17	16.19
Maximum width of head	0.97-1.58	1.24±0.23	18.54
Length of hind tibia	0.92-1.22	1.07±0.12	11.21

g) Major worker

(This originates from a second type of 3rd instar larva which after two successive moults changes into the major worker).

Head much darker than rest of the body. Head oval, brain visible but much reduced.

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Mandibles strongly sclerotized with well differentiated notches and fully developed teeth. Antennae with 17 segments, first article as long as second and third combined. Abdomen with a pair of styli, tarsi 4-jointed (Table VIII).

Table VIII. Biometric analysis of different characters of major worker (measurements in mm)

Characters	Range (N=20)	Mean±S.D.	C.V.
Total body length	4.86-5.52	5.11±0.24	4.69
Head length to side base of mandible	1.12-1.33	1.23±0.09	7.31
Maximum width of head	1.48-1.58	1.56±0.05	3.20
Length of hind tibia	1.12-1.28	1.16±0.06	5.17

2. Soldier line

In spite of best efforts, first and second instar pre-soldiers could not be found in the field nest population. The most primitive pre-soldier instar found in nest was third instar which is described.

a) Third instar pre-soldiers

Head and body whitish, head nearly round. Mandibles differentiating within the intact cuticle of older second instar pre-soldier; older mandible with first marginal tooth present, anterior margins wavy; new mandible developing within older mandible provided with minute tooth much below the first marginal tooth of older mandible. Antennae 16 segmented (Fig. 2, Table IX).

Table IX. Biometric analysis of different characters of third instar pre-soldier (measurements in mm)

Characters	Range (N=5)	Mean±S.D.	C.V.
Total body length	3.48-4.04	3.76±0.21	5.58
Head length to side base of mandible	0.87-1.02	0.92±0.06	6.52
Maximum width of head	0.92-1.12	0.99±0.07	7.07
Length of hind tibia	0.76-0.87	0.83±0.04	4.81

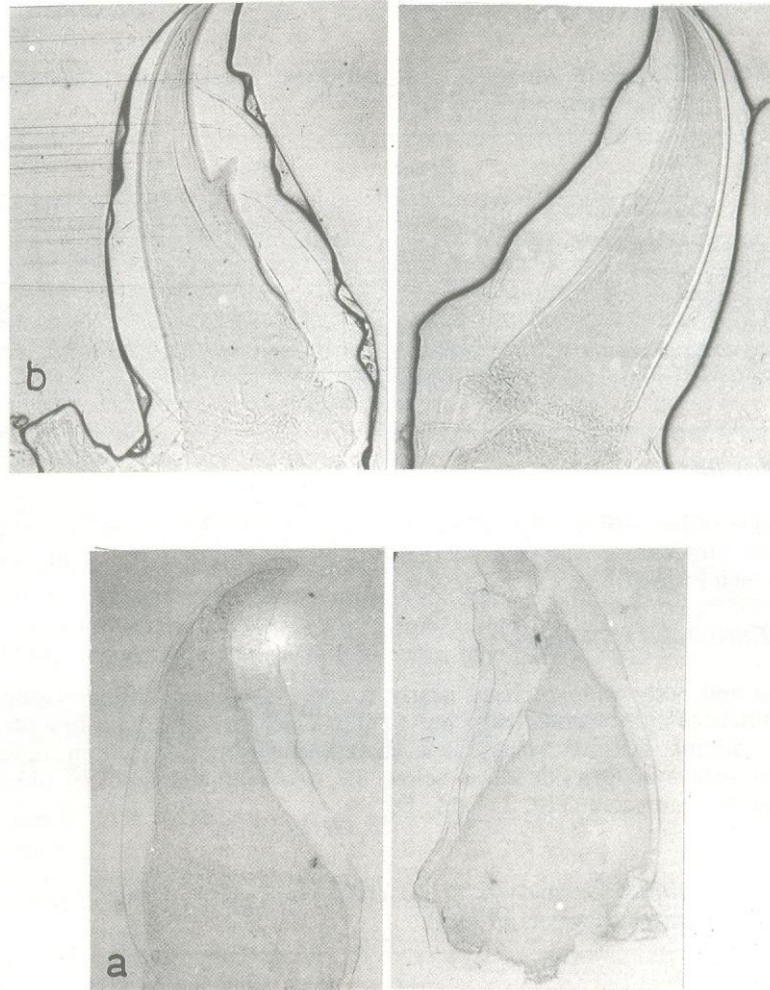


Fig. 2. Stages of mandibular development during soldier differentiation. a. third instar pre-soldier; b. fifth instar pre-soldier.

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Like third instar pre-soldier, but with left mandible tooth much more developed.

Table X. Biometric analysis of different characters of fourth instar pre-soldier (measurements in mm)

Characters	Range (N=5)	Mean±S.D.	C.V.
Total body length	3.43-4.35	3.84±0.38	9.97
Head length to side base of mandible	0.71-0.92	0.80±0.08	10.00
Maximum width of head	0.87-1.12	0.98±0.08	8.16
Length of hind tibia	0.87-0.97	0.92±0.03	3.26

c) Fifth instar pre-soldier

Head and body whitish like fourth instar. Head still round, left mandible with well differentiated tooth and right mandible with a distinct denticle, tips of mandible slightly more sclerotized (Table XI).

Table XI. Biometric analysis of different characters of fifth pre-soldier instar (measurements in mm)

Characters	Range (N=5)	Mean±S.D.	C.V.
Total body length	3.78-4.35	3.98±0.23	5.77
Head length to side base of mandible	0.76-0.92	0.82±0.07	8.56
Maximum width of head	0.97-1.07	1.00±0.04	4.47
Length of hind tibia	0.81-1.02	0.84±0.10	11.40

d) Sixth instar pre-soldier

Head elongately oval, mandible with reddish brown in upper two third, bases not sclerotized. Antennae slightly more sclerotized than 5th instar, distal articles not distinctly darker than basal one (Table XII).

Table XII. Biometric analysis of different characters of sixth instar pre-soldier (measurements in mm)

Characters	Range (N=5)	Mean±S.D.	C.V.
Total body length	4.04-4.60	4.28±0.22	5.14
Head length to side base of mandible	0.92-1.12	1.03±0.07	6.69
Maximum width of head	1.02-1.17	1.12±0.06	5.35
Length of hind tibia	0.97-1.02	1.00±0.02	2.00

e) Soldier

Final instar with mandibles strongly sclerotized. Antennae with distal articles darker, proximal lighter in colour (Table XIII).

Table XIII. Biometric analysis of different characters of soldier (measurements in mm)

Characters	Range (N=20)	X±S.D.	C.V.
Total body length	4.64-5.77	5.38±0.28	5.20
Head length to side base of mandible	1.41-1.49	1.43±0.02	1.39
Maximum width of head	1.18-1.20	1.22±0.03	2.45
Length of hind tibia	1.13-1.29	1.17±0.04	3.41

DISCUSSION

Developmental pathways of only few species of fungus growing termites are known. Noirot (1985a) reported that development stages through which the worker passes after differentiation from third instar larva may vary in *Macrotermitinae*. Okot Kotber (1985) reported that in case of *Macrotermes michaelsoni* the third stage larva moults into adult workers both major and minor. Akhtar and Rana (1988) reported that in a colony of *Odontotermes gurdaspurensis* worker develops after five successive moults. Present studies with a field colony of *O. redemanni* revealed that the egg hatches into larva and this larva after two moults may differentiate into worker line or the soldier line (Fig. 3).

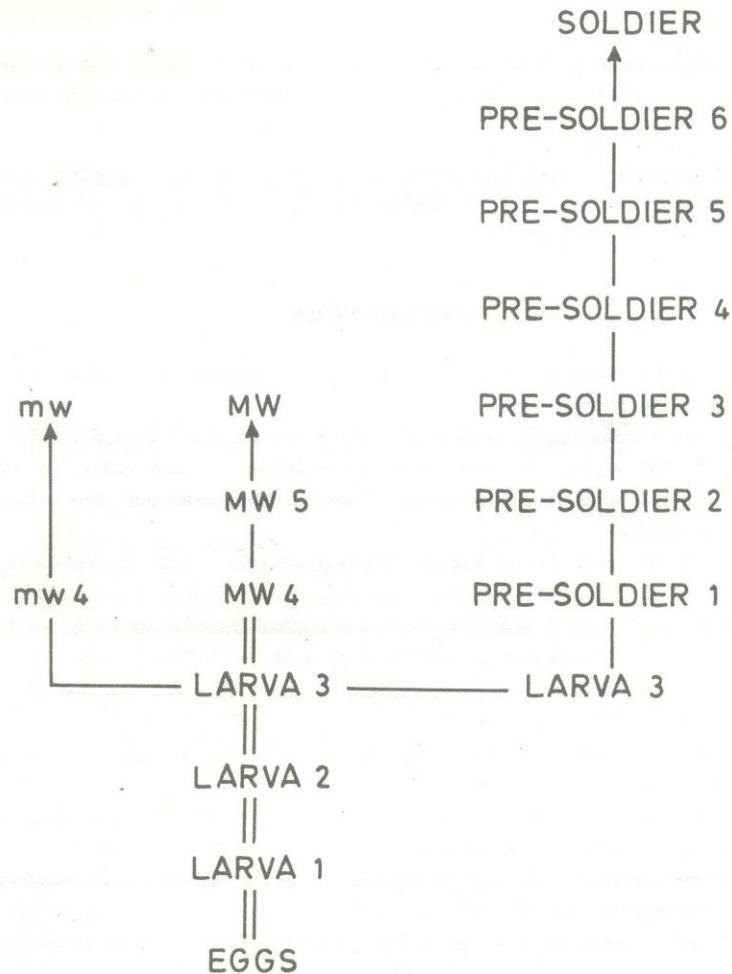
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Fig. 3. A scheme of post embryonic development in a mature colony of *O. redemanni*. L₁-L₃, larval instars; Mw₄-Mw₅, minor worker instar; Mw, minor worker; 1-6, presoldiers.

The third instar larvae are of two types. One type leads to minor worker after one moult; and the second type of larvae after two successive moults change into the major worker.

The development of minor pre-soldiers from third instar is a common phenomenon in *Macrotermitinae* (Noirot, 1955, 1969) and the results obtained from causal observations of field material and from laboratory incipient colonies where only minor soldiers are produced show that *M. michaelsoni* is no exception (Okot Kotber,

1981a,b).

Present studies with a field colony of *O. redemanni* reveal that the pre-soldier differentiates from third larva which after six successive moults changes into a mature soldier.

These developmental variations further confirm the doubts prevailing amongst the termitologists about the existence of sibling species like *O. obesus*, *O. redemanni*, *O. gurdaspurensis* and *O. assamensis*.

REFERENCES

- AHMAD, M., 1950. The phylogeny of termite genera based on imago-worker mandibles. *Bull. Am. Mus. Nat. Hist.*, **95**: 37-86.
- AKHTAR, M. S., 1974. Zoogeography of the termites of Pakistan. *Pakistan J. Zool.* **6**: 85-104.
- AKHTAR, M.S. AND RANA, S., 1988. Cast polymorphism in field colony of *Odontotermes gurdaspurensis* Holmgrin and Holmgrin (*Termitidae: Macrotermitinae*). *Proc. Pakistan Congr. Zool.*, **8**: 181-194.
- BOSE, G., 1984. *Termite fauna of India*. Record of Zoological Survey of India. Occasional Paper No. **49**: 1-271.
- CHHOTANI, O.B., 1980. Termite pests of agriculture in the Indian region and their control. Zoological Society of India, Technical Monograph No. 4, pp. 1-84.
- EMERSON, A.E., 1945. The neotropical genus *syntermes* (*Isoptera: Termitae*). *Bull. Am. Mus. Nat. Hist.*, **83**: 427-472.
- NOIROT, C., 1969. Formation of castes in higher termite. In: *Biology of termites* (eds. K. Krishna and F.M. Weesner, pp. 311-350. Academic Press, New York & London.
- NOIROT, C., 1985. The caste system in higher termites. In: *Caste differentiation in social insects* (eds. J.A.L. Watson, B.M. Okot-Kotber and C. Noirot, Pergamon Press, Oxford.
- NOIROT, C., 1985a. Recherches sur le polymorphisme des termites superviseurs (*Termitidae*). *Ann. Sri. Natl. Zool. Biol. Animale*, **17**: 399-595.
- OKOT-KOTBER, B.M., 1981a. Instar and polymorphism of castes in *Macrotermes michaelseni* (*Isoptera, Macrotermitinae*). *Insect Sociaux*, **28**: 233-246.
- OKOT-KOTBER, B.M., 1981b. Polymorphism and development of the first progeny in incipient colonies of *Macrotermes michaelseni* (*Isoptera: Macrotermitinae*). *Insect. Sci. Application*, **1**: 147-150.
- SOKAL, R.P. AND ROHLF, F.J., 1973. *Introduction to Biostatistics*. Toppan Company, Japan.
- Thorne, B.L., 1985. Numerical and biomass caste proportions in colonies of the termites *Nasutitermes ephratae* (*Isoptera, Termitidae*). *Insects Soci.*, **32**: 411-426.

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