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MORPHOMETRIC ANALYSIS OF POPULATION SAMPLES OF SOLDIER CASTE OF *ODONTOTERMES JAVANICUS* HOLMGREN (ISOPTERA: TERMITIDAE, MACROTERMITINAE)

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Abstract
In order to study morphometric Variations in *Odontotermes javanicus* Holmgren,. Samples from five different nests were statistically analysed for mean, standard deviation, standard error, coefficient of variability and confidence interval (95/) and analysis of variance (Model II ANOVA), The mean values of the different population samples were compared with the help of student 't' test according to Minitab version and Sokal and Rohlf [1973]. In the study of external characters, measurements form a very important component particularly for identification of species. However, the reliability of the measurements depends on the extent of variability which the structures show within and between colonies.
For each individual soldier, the following nine parameters were measured: i) Length of head to side base of mandibles ii) Width of head at side base of mandibles iii) Width of head at the posterolateral ends of antennal carinae iv) Maximum width of Head v) Length of left mandible vi) Tooth of left mandible from tip vii) Length of Pronotum viii) Width of Pronotum ix) Length of Postmentum x) Width of postmentum.
This study was carried out in the Department of Zoology, University of the Punjab, Lahore, Pakistan.

Keywords: Morphometric variability, *Odontotermes javanicus,* soldier, termite.

INTRODUCTION
The Genus *Odontotermes* is widely distributed in the Oriental and Ethiopian regions of the world. Today, almost 2300 species of termites are known worldwide [Sen-Sarma *et al.* 1975]. As far as the origin of genus *Odontotermes* is concerned, it is believed that this genus originated from Ethiopian region and

then dispersed to oriental region, in the early Miocene period through West Asia [Emerson 1955, Krishna 1970, Thakur 1976]. *Odontotermes javanicus* Holmgren is found in the Malaya Peninsula and Indonesia (Sumatra, Java and Madura). It is common in Java. It is a common pest of tea and palms in Malaya and rubber in Vietnam. The nest lies underground, sometimes at the base of trees occasionally in earthen walls in houses. It contains several fungus combs in between which lies a royal chamber which contains a king and a queen. Termitophiles are commonly found in the combs [Roonwal 1970]. This species is not found in Pakistan. Morphological features of termites are very important in their taxonomy and classification. Only a few studies on Morphometric variation in termites have been made [Ahmad 1949, Roonwal 1970, Chhotani and Das 1979, Chhotani 1981, Akhtar and Anwar 1991, Akhtar and Ahmad 1991, Coronel and Porcel 2002].

The morphometric analysis of *O. javanicus* Holmgren presented in this paper will provide a standard of comparison for specimens from different localities of the range of that species and other species of the genus. The photographs of the specimens have also been prepared to present exact morphological appearance of various taxonomic characters. Another aim of this study is to determine whether different populations can be differentiated statistically or not by measurements and indices calculated for the imago and soldier caste. Internest and intranest comparisons were also made for this species.

The objective of this work is to contribute to a better taxonomic knowledge of this species by means of the study of the intracolonial and intercolonial variations in the soldier caste.

MATERIALS AND METHODS

The present study is based on the preserved material available in the collection of Dr. Muzaffar Ahmad, presently in the custody of. Dr. M. Saeed Akhtar. Specimens from the samples were picked up at random and measured under stereoscopic binocular microscope with built in magnification changer. Measurements were taken with the aid of calibrated ocular micrometer. Diagrams of the mandibles and postmentum were prepared by Olympus bimocular with attached camera.

Taxonomic terms and measurements used in the present study are as explained by Emerson [1945, 1952], Ahmad [1965] and Akhtar [1975].

SOLDIERS

1. The length of mandible is the distance from the condyle to the tip.
2. The tooth from the tip is the distance from the tip to the base of the tooth.
3. The length of postmentum is the median length of the sclerotized portion.

INDICES

1. Mandibular tooth index (TLT/LLM) is the distance of tooth of left mandible from tip/Length of left mandible.
2. Head mandibular index (LLM/LHSBM) is the length of left mandible/length of head to sidebase of mandibles.
3. Head width mandibular index (LLM/MWH) is the length of left mandible/maximum width of head.

ODONTOTERMES JAVANICUS HOLMGREN

Odontotermes (Odontotermes) javanicus: Holmgren [1912, 1914], Kemner [1934], Ahmad [1958].

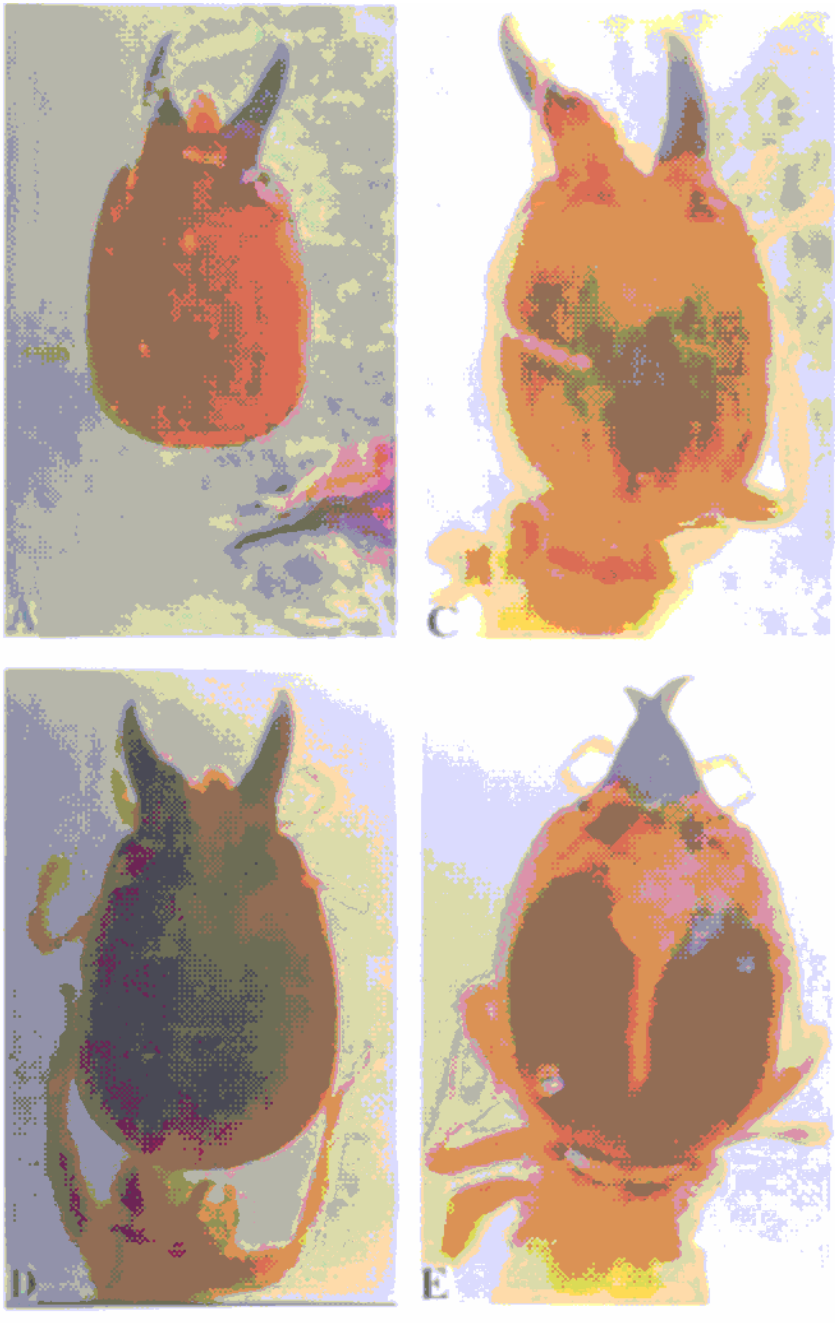

Plate 1a: Variation in head capsules of soldiers of O. javanicus Holgren; A) Malaya: Perak (X7), C) Java: Depok (X9), D) Malaya: Sarawak (X9), E) Java: Buitenzorg (X9).

Soldiers (Plate-1 a,b; Tables 1-3)

The soldier of *O. javanicus* Holmgren is characterized by uniformly coloured antennae; head subrectangularly oval, gradually sloping anteriorly, widest in posterior half; mandibles short, thick and stout, much shorter than head; left mandible with a short, laterally directed tooth a little below middle; inner edge of the left mandible below the tooth strongly convex; postmentum subrectangular, broad posteriorly.

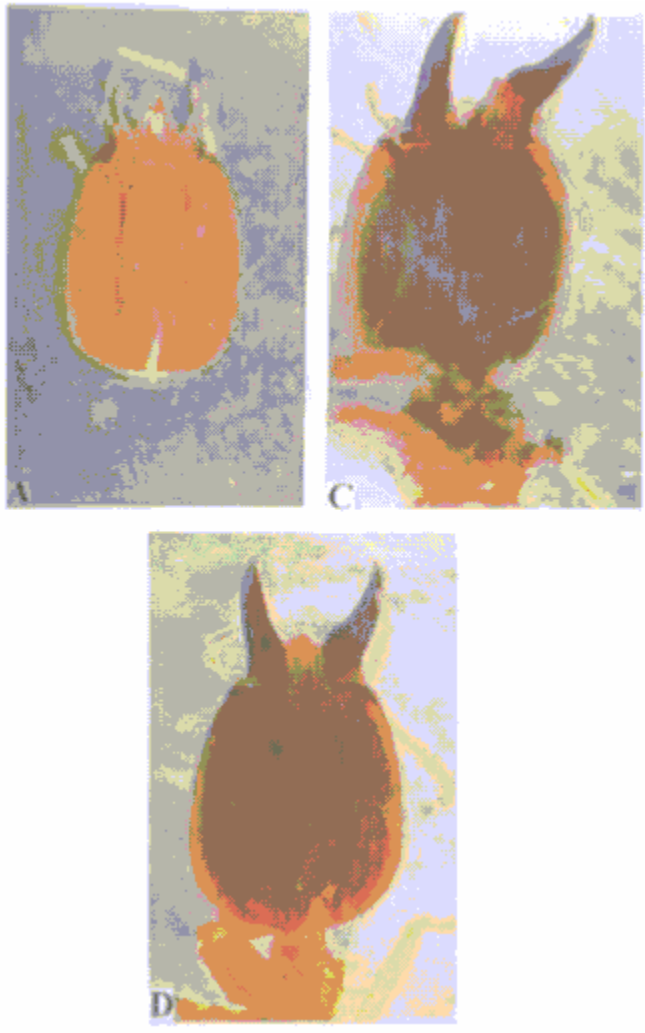

Plate 1b: Variation in postmentum of soldiers of O. javanicus Holgren; A) Malaya: Perak (X7), C) Java: Depok (X9), D) Sarawak (X9).

MATERIALS EXAMINED

Malaysia

A. Malaya: Perak, 2.mi-ek, Tapah-Tanah, Rata, soldiers and workers, collected by D.H. Kistner, 7.6.1973, Nest T-629.

D. Sarawak: Borneo, soldiers and workers, S.F. Light collection, 1383 from Holmgren, determined by N. Holmgren.

Indonesia

B. Java: Buitenzorg, Autotype, metatype, soldiers and workers, collected by H.V. Buttel-reepen, determined by N. Holmgren, redetermined and compared by A.E. Emerson.

C. Java: Depok, soldiers and workers, from S.F. Light collection, 1383 from Holmgren, determined by N. Holmgren.

E. Java: Buitenzorg, soldiers and workers, collected by H.V. Buttel-reepen, determined by N. Holmgren, redetermined by A.E. Emerson.

RESULTS

Internest comparisons revealed that there were non significant differences among samples collected from different localities for the parameters: Length of head to Side base of Mandible **(**F., 0.16; d.f., 1:6; P>0.05) ; Width of head at side base of Mandible (F., 3.39; d.f., 1:6; Length of left mandible (F., 17.17; d.f., 1:6; P<0.05); Width of Pronotum (F., 4.34; d.f., 1:6; P>0.05); Width of Postmentum (F., 0.35; d.f., 1:6; P>0.05); Further comparisons for different population combinations revealed significant differences for the parameters; Width of head at the posterolateral ends of antennal carinae **(**F., 14.94; d.f., 1:6; P<0.05) Maximum of width (F., 0.86; d.f., 1:6; P>0.05); Tooth of left mandible from tip (F., 2.75; d.f., 1:6; P>0.05) ; Length of Pronotum (F., 59.89; d.f., 1:6; P>0.05) ; Length of Postmentum (F., 48.70; d.f., 1:6; P<0.05) as shown in Table 1.

Table 1: Internest Morphometric variations in taxonomic parameters of the soldier caste of *O. javanicus* Holmgren. Samples followed by similar letters indicate non-significant differences in mean values by 't'-test (P>0.05).

Nest Sample	N	O.R	$\overline{X}$	S.D.	S.E.	95% C.I	C.V
Length of head to side base of mandibles							
A	6	2.00-2.65	2.39	0.2396	0.0978	2.14-2.64	10.0
B	2	2.27-2.37	2.32	0.0707	0.0500	1.68-2.95	3.04
C	1	2.22	2.22	-	-	-	-
D	1	2.16	2.16	-	-	-	-
E	1	1.86	1.86	-	-	-	-
							F., 0.16; d.f., 1:6; P>0.05.
Width of head at sidebase of mandibles							
A	6	1.00-1.10	1.03	0.0408	0.0167	0.99-1.07	3.94
B	2	1.08-1.10	1.09	0.0141	0.0100	0.96-1.21	1.20
C	1	1.15	1.15	-	-	-	-
D	1	1.13	1.13	-	-	-	-
E	1	0.99	0.99	-	-	-	-
							F., 3.39; d.f., 1:6; P>0.05.
Width of head at the posterolateral ends of antennal carinae							
A[a]	6	1.60-1.70	1.65	0.0447	0.0183	1.60-1.69	2.76
B[a]	2	1.41-1.54	1.47	0.0919	0.0650	0.65-2.30	6.23
C	1	1.44	1.44	-	-	-	-
D	1	1.39	1.39	-	-	-	-
E	1	1.22	1.22	-	-	-	-
							F., 14.94; d.f., 1:6; P<0.05.

			Maximum width of head				
A	6	1.83-2.03	1.94	0.0755	0.0308	1.85-2.01	3.89
B	2	1.83-1.93	1.88	0.0707	0.0500	1.24-2.51	3.76
C	1	1.99	1.99	-	-	-	-
D	1	1.93	1.93	-	-	-	-
E	1	1.67	1.67	-	-	-	-
						F., 0.86; d.f., 1:6; P>0.05.	
			Length of left mandible				
A	6	1.11-1.15	1.13	0.01633	0.00667	1.12-1.15	1.43
B	2	1.10-1.21	1.19	0.0212	0.0150	1.00-1.38	1.77
C	1	1.19	1.19	-	-	-	-
D	1	1.08	1.08	-	-	-	-
E	1	1.06	1.06	-	-	-	-
						F., 17.17; d.f., 1:6; P<0.05.	
			Tooth of left mandible from tip				
A	6	0.65-0.75	0.7000	0.0447	0.0183	0.6531-0.7469	6.38
B	2	0.61-0.67	0.6400	0.0424	0.0300	0.2588-1.0212	6.62
C	1	0.70	0.70	-	-	-	-
D	1	0.64	0.64	-	-	-	-
E	1	0.57	0.57	-	-	-	-
						F., 2.75; d.f., 1:6; P>0.05.	
			Length of pronotum				
A	6	0.80-0.85	0.8333	0.0258	0.0105	0.8062-0.8604	3.09
B	2	0.67-0.69	0.6800	0.0141	0.0100	0.5529-0.8071	2.07
C	1	0.74	0.74	-	-	-	-
D	1	0.76	0.76	-	-	-	-
E	1	0.64	0.64	-	-	-	-
						F., 59.89; d.f., 1:6; P<0.05.	
			Width of pronotum				
A[a]	6	1.35-1.40	1.3917	0.0376	0.0154	1.3522-1.4312	2.76
B[a]	2	1.31-1.35	1.3300	0.0283	0.0200	1.0759-1.5841	2.12
C	1	1.38	1.38	-	-	-	-
D	1	1.31	1.31	-	-	-	-
E	1	1.19	1.19	-	-	-	-
						F., 4.34; d.f., 1:6; P>0.05.	
			Length of postmentum				
A	6	1.40-1.45	1.4167	0.0258	0.0105	1.3896-1.4438	1.82
B	2	1.22-1.28	1.2500	0.0424	0.0300	0.8688-1.6312	3.39
C	1	1.44	1.44	-	-	-	-
D	1	1.41	1.41	-	-	-	-
E	1	1.19	1.19	-	-	-	-
						F., 48.70; d.f., 1:6; P<0.05.	
			Width of postmentum				
A	6	0.65-0.75	0.69	0.0492	0.0201	0.64-0.74	7.11
B	2	0.67	0.67	-	-	-	-
C	1	0.64	0.64	-	-	-	-
D	1	0.69	0.69	-	-	-	-
E	1	0.64	0.64	-	-	-	-
						F., 0.35; d.f., 1:6; P>0.05.	

Sample C, D and E were not included in morphometric analysis.
N = Number of samples; O.R. = Observed range; X = Mean; S.D. = Standard Deviation;
S.E. = Standard Error; C.I. = Confidence Interval; C.V.= Coefficient of variance;

DISCUSSION

Genus *Odontotermes* is the most prolific and the most widely distributed genus of the termites in the Indo-Malayan region but detailed studies regarding morphometric variations are not given in literature. Similarly, only a few reports are available about morphometric variations in termites. For example, Roonwal

and Sangal [1957] studied variability in mandibles of soldier caste of termites *Odontotermes obesus* (Rambur). He analyzed three population samples I, II and III from three different mounds of India in the vicinity of Dehra Dun (in the western Sub-Himalayan region of Utter Pradesh, cc.600 meters above sea level), two from the New Forest Estate and one from the Jhajra Forest, and reported that the data will serve as a standard of comparison for other species of the genus *Odontotermes*.

Chhotani and Das [1979] studied variation in size and morphometric analysis of soldier caste of *Heterotermes indicola*.

Akhtar and Rizwana [1991] studied variability of soldier caste of termite *Odontotermes obesus* from various localities of Pakistan. They reported variability in different morphological parameters of species and gave dendrogram of relations among 5 OTU's based on WVGM clustering procedure of correlation coefficient. The pooled data indicate that the samples are more variable (Table 2) for length of pronotum ($\overline{X}$ = 11.10) as compared to other parameters. Length of left mandible is more stable and less variable character (C.V. = 3.96) for this species. The smallest specimen (E) belonged to Java and was determined by Holmgren and redetermined by Emerson (Plate 1).

Table 2: Statistics for various parameters used in this study for *O. javanicus* Holmgren, all localities combined.

Parameters	N	O.R.	$\overline{X}$	S.D.	S.E.	95% C.I.	C.V.
Length of head to side base of mandibles	11	1.86-2.65	2.29	0.2372	0.0715	2.13-2.45	10.35
Width of head at side base of mandible	11	0.99-1.15	1.05	0.0570	0.0172	1.02-1.09	5.42
Width of head at the posterolateral ends of antennal carinae	11	1.22-1.70	1.53	0.1517	0.0457	1.43-1.63	9.91
Maximum width of head	11	1.67-2.03	1.90	0.1019	0.0307	1.84-1.97	5.36
Length of left mandible	11	1.06-1.21	1.13	0.0448	0.0135	1.10-1.16	3.96
Tooth of left mandible from tip	11	0.57-0.75	0.67	0.0555	0.0167	0.63-0.71	8.28
Length of pronotum	11	0.64-0.85	0.78	0.087	0.0263	0.72-0.84	11.10
Width of pronotum	11	1.19-1.40	1.34	0.0630	0.0190	1.36-1.39	4.70
Length of postmentum	11	1.19-1.45	1.37	0.0982	0.0296	1.31-1.44	7.16
Width of postmentum	11	0.64-0.75	0.69	0.0483	0.0146	0.66-0.72	7.00

Present studies revealed that length of postmentum is a very important character. Internest variations are shown in plate 1 (a and b) and all the samples showed differences. The tooth of left mandible from tip, which is another very important character for distinguishing different species in the genus, varied from 0.57-0.75 mm, in the pooled data. Highest tooth distance was recorded for sample A (Table 1).

In the present studies, internest variations were studies for the soldier caste. As these morphometric variations show all sort of overlapping, further biochemical and karyotype studies are required.

INDICES

i) Mandibular Tooth Index (TLT/LLM)

The index value varied from 0.54-0.65. The mean values were 0.62, 0.55, 0.61, 0.59 and 0.54 for samples A, B, C, D and E, respectively (Map). Sample B (Java: Buitenzorg) has the highest value of coefficient of variability (C.V. = 2.56) (Table 3).

ii) Head Mandibular Index (LLM/LHSBM)

The index value varied from 0.43-0.57. The mean values were 0.48, 0.50, 0.54, 0.50 and 0.57 for samples A, B, C, D and E, respectively (Map). Sample A (Malaya: Perak) has the highest value of coefficient of variability (C.V. = 9.16) (Table 3).

iii) Head Width Mandibular Index (LLM/MWH)

The index value varied from 0.50-0.62. The mean values were 0.59, 0.56, 0.62, 0.56 and 0.62 for samples A, B, C, D and E, respectively (Map). Sample B (Java: Buitenzorg) has the highest value of coefficient of variability (C.V. = 15.10) (Table 3).

Table 3: Statistics of various indices used in this study for *O. javanicus* Holmgren.

Nest Sample	N	O.R	$\overline{X}$ *	S.D.	S.E.	95% C.I	C.V
i)	Mandibular Tooth Index (TLT/LLM)						
A	6	0.61-0.65	0.62	0.01506	0.00615	0.61-0.64	2.41
B	2	0.54-0.56	0.55	0.0141	0.0100	0.42-0.68	2.56
C	1	0.61	0.61	-	-	-	-
D	1	0.59	0.59	-	-	-	-
E	1	0.54	0.54	-	-	-	-
*Average mean value = 0.58.							
ii)	Head Mandibular Index (LLM/LHSBM)						
A	6	0.43-0.55	0.48	0.0437	0.0178	0.43-0.52	9.16
B	2	0.49-0.50	0.50	0.00707	0.00500	0.43-0.56	1.42
C	1	0.54	0.54	-	-	-	-
D	1	0.50	0.50	-	-	-	-
E	1	0.57	0.57	-	-	-	-
*Average mean value = 0.52.							
iii)	Head Width Mandibular Index (LLM/MWH)						
A	6	0.57-0.62	0.59	0.02229	0.00910	0.56-0.61	3.78
B	2	0.50-0.62	0.56	0.0829	0.0600	0.20-1.32	15.1
C	1	0.62	0.62	-	-	-	-
D	1	0.56	0.56	-	-	-	-
E	1	0.62	0.62	-	-	-	-
*Average mean value = 0.52.							

References

Ahmad, M. (**1949**) “On the identity *of Odontotermes (Isoptera : Termitidae*)”, *Amer. Mus. Novit.*, **1392**, 1-11.

Ahmad, M. (**1958**) “Key to the Indomalayan Termites”, *Ibid,* **4**, 33-198.

Ahmad, M. (**1965**) “Termites (Isoptera) of Thailand”, *Bull. Amer. Mus. Nat. Hist.,* **131**, 1-113.

Akhtar, M.S. (**1975**) “Taxonomy and zoogeography of the termites (Isoptera) of Bangladesh”, *Bull. Dept. Zool. Univ. Punjab* (N.S.), 1-199.

Akhtar, M.S. and Ahmad, N. (**1991**) “Morphometric analysis of *Odontotermes assamensis* Holmgren, with a note on its taxonomic status”, *Punjab Univ. J. Zool.,* **7**, 27-36.

Akhtar, M.S. and Anwar, R. (**1991**) “Variability in the size of the soldier caste of the termite *Odontotermes obesus* (Rambur)”, *Pakistan J. Zool.,* **23**(2), 169-174.

Akhtar, M.S. and Rizwana (**1991**)

Chhotani, O.B. (**1981**) “Morphometric analysis of populations from four different types of mounds of the Indian termite *Odontotermes obesus* (Rambur)”, In: P.E. Howse and J.L. Clement (Eds.) *Biosystematics of Social Insects*, Academic Press, London and New York, pp.147-161.

Chhotani, O.B. (**1997**) “Fauna of India Isoptera (Termites)”, Vol. II, Zoological Survey of India, Calcutta.

Chhotani, O.B. and Das, B.C. (**1979**) “Variability and morphometric analysis of the soldier caste in *Heterotermes indicola* (Wasmann)”, *Proceedings of Symposium on Zoological Survey of India*, **1**, 47-52.

Emerson, A.E. (**1945**) “The neotropical genus *syntermes* (Isoptera: Termitidae)” *Bull. Amer. Mus. Nat. Hist*., **83**, 427-472.

Emerson, A.E. (**1952**) ”The biogeography of termitdes”, *Bull. Amer. Mus. Nat. Hist*., **99**, 217-225.

Emerson, A.E. (**1955**) “Geographical origin and disperson of termite genera”, *Fieldian Zool. Chicago*, **37**, 465-521.

Holmgren, N. (**1912**) “Termiten Studien”, *Systematik der Termiten Die Familie* **37**(26), 545-553. “Metatermitidae”, *K. Svenska Vetensk. Akad. Handl*., **48**(4), 1-166.

Holmgren, N. (**1914**) Wissenschaftliche Ergebnisse einer Forschungstreise nach Ostindien, ausgefuhrt im Auftrage der Kgl Preuss, Akademie der Wissenschaften zu Berlin von H. V. Buttel-Reepen. III. Termiten aus Sumatra, Java, Malacca und Ceylon. Gesammelt von Herrn Prof. Dr. V. Buttel-Reepen in den Jahren 1911-1912. *Zool. Jahrb. Abst. Syst*., **36**(2-3), 229-290.

Kemner, N.A., (**1934**) “Systematische und biologische Studien über de Termiten Javas und Celebes“, *K. Svenska Vetensk Akad. Handl.,* **13**, 1-241.

Krishna, K. (**1970**) “Taxonomy, phylogeny and distribution of termites”, In: K. Krishna and F.M. Weesner (Eds.), *Biology of Termites*, Vol.2, New York, pp.127-150.

Roonwal, M.L. (**1970**) “Measurements of termites (Isoptera) for taxonomic purposes”, *J. Zool. Soc*. India,

Roonwal, M.L. and Sen-Sarma, P.K. (**1956**) "Systematics of Oriental termites (Isoptera). No.3. Zoological Survey of India collections from India and Burma with new termites of the genus *Parrhinotermes, Macrotermes, Hypotermes* and *Hospitalitermes*", *Indian J. Agric. Sci*., **26**, 1-37.

Roonwal, M.L. and Sangal, S.K. (**1957**) "Variability in the mandibles of soldiers in the termite *Odontotermes obesus* (Rambur) (Isoptera: Termitidae)", *Rec. Zool. Surv. India (formerly Rec. Indian Mus.), Calcutta*, **55**(1-4), 1-22.

Sen-Sarma*, et al*., (**1975**) "Wood destroying termites of India", Final Tech. Report, PL-480 Project A7-FS-58.

Sokal, R.R. and Rohlf, J.F. (**1973**) "Introduction to Biostatistics", Toppan Company, Tokyo, Japan.

Thakur, M.L. (**1976**) "Zoogeography of termite genus *Odontotermes* in the Indian Region (Isoptera: Termitidae: Macrotermitinae)", *Indian For*., **102**(8), 498-505.