

FOSSIL REMAINS OF *CERVUS SIVALENSIS* FROM THE MIDDLE SIWALIKS OF PAKISTAN

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Abstract An isolated third molar of left mandible in a well-preserved condition is described from type locality Dhok Pathan, Chakwal district, the Punjab province, Pakistan and a fragment of right mandible having M₁ from Hasnot, (Middle Siwaliks) Jhelum district, the Punjab province, Pakistan. The comparison of the specimens under study with the known material of the genus *Cervus* shows that they are referable to the species *Cervus sivalensis* Lydekker.

Key words: Molar, Dhok Pathan, Hasnot and *Cervus*.

INTRODUCTION

The cervids appeared in Oligocene with small size and lack of antlers. Early small cervids, e.g., *Eumeryx* and *Iberomeryx*, appeared in the Middle Oligocene sediments of Central Asia from where they dispersed to Europe and North America, most probably, in the Early Miocene (Savage and Russell, 1983). The first appearance of cervids in South America and Africa has been reported from the Pleistocene (Romer, 1960).

Cervids are included in class Mammalia, family Cervidae, order Artiodactyla and suborder Ruminantia. Keeping in view, the taxonomic details of the Siwalik cervids given by Lydekker (1876, 1884), Brown (1926), Colbert (1935) and Azziaroli (1954) the following nomenclature is considered valid:

Cervus simplicidens Lydekker, 1876.

Cervus triplidens Lydekker, 1876.

Cervus sivalensis Lydekker, 1884.

Cervus punjabiensis Brown, 1926.

Cervus colberti Azzaroli, 1954.

Arif and Raza (1991) and Akhtar *et al.* (1999) have reported a good collection of cervids consisting of mandibular and maxillary fragments and isolated molars from the Upper Siwaliks of Mirpur and Eastern Potwar areas. Arif and Shah (1991) added a new species *Cervus rewati* to the family Cervidae. *Cervus rewati* can be recognized by the

presence of basic characteristic features such as presence of median basal pillar, pronounced anterior folds on the molars and small sized teeth. The classification is based upon Simpson (1945).

ABBREVIATIONS

GSI	Geological Survey of India, Calcutta.
L	Maximum preserved anteroposterior crown length of tooth.
M1	First upper molar.
M2	Second upper molar.
M3	Third upper molar.
mm	Millimeter.
P.U.P.C.	Punjab University Palaeontological Collection, stored in the Department of Zoology, Lahore, Pakistan.
W	Maximum preserved crown width of tooth.
W/L Index	Crown shape index (tooth is narrow crowned when it is 50-100 and broad crowned when 101-125).

SYSTEMATICS

Class:	Mammalia Linnaeus, 1758
Sub class:	Theria Parker and Haswell, 1897
Infra class:	Eutheria Gill, 1872
Super order:	Paraxonia Marsh, 1884
Order:	Artiodactyla Owen, 1848
Sub order:	Ruminantia Scopoli, 1777
Infra order:	Pecora Linnaeus, 1758
Super family:	Cervoidea Simpson, 1931
Family:	Cervidae Gray, 1821
Sub family:	Cervinae Baird, 1857
Genus:	Cervus Linnaeus, 1758
Species:	Cervus <i>sivalensis</i> Lydekker, 1876.

(Figs. 1, 2).

Holotype

A right mandibular ramus with M₂₋₃ (G.S.I. No. B215).

Locality

Maili, Punjab. (Lydekker, 1884, did not mention definite locality).

Horizon

Upper Siwaliks.

Diagnosis

A large cervid with relatively hypsodont molars. The skull and antlers resemble these portions in *Cervus duvaucelli*, the skull by virtue of the frontal concavity at the orbits and the forward swells at the pedicles. The lacrymal vacuity is smaller than in *Cervus duvaucelli*. The brow tine of the antlers arises immediately above the burr, and forms an obtuse angle with the beam (Colbert, 1935).

MATERIAL STUDIED

P.U.P.C. No. 83/641 (Fig. 1).

An isolated third molar of left mandible.

P.U.P.C. No. 85/95 (Fig. 2).

A fragment of right mandible having M_{2,3}.

Locality

For P.U.P.C. No. 83/641, Dhok Pathan, Chakwal district, the Punjab province, Pakistan and for P.U.P.C. No 85/95, Hasnot, Jhelum district, the Punjab province, Pakistan.

Horizon

Middle Siwaliks.

Description**P.U.P.C.No. 83/641 (Fig. 1)**

It is in an excellent state of preservation in which enamel layer is quite thick and rugose. It is extremely narrow crowned tooth. (Table 1). The median basal pillar is elongated and strong. The principal cusps are well preserved. The protoconid and outer border of metaconid are roughly U-shaped. The entoconid is crescentic in outline and hypoconid is rounded in the middle. The stylids are moderately developed while the central cavities are well developed. The talonid is strong and well preserved. It is very similar in structure to the other cusps of the the crown.

P.U.P.C. No. 85/95 (Fig 2)

It includes a fragment of right mandible having M_3 which is in an excellent state of preservation. M_2 is a narrow crowned tooth (Table II) while M_3 is an extremely narrow crowned tooth (Table I). The median basal pillar is strong and well developed. The major cusps i.e. protoconid, metaconid, entoconid and hypoconid are prominent. The stylids are moderately developed. The median ribs are strong and wide. The anterior median rib is rounded and the posterior median rib is smaller than the anterior one. The central cavities are evidently distinct. In M_3 the talonid is crescentic.



Fig I: *Cervus sivalensis* Lydekker, an isolated third molar of left mandible (P.U.P.C No. 83/641), collected from Dhok Pathan, Chakwal district, the Punjab province Pakistan. I) Lingual view, II) Crown view. III) Buccal view

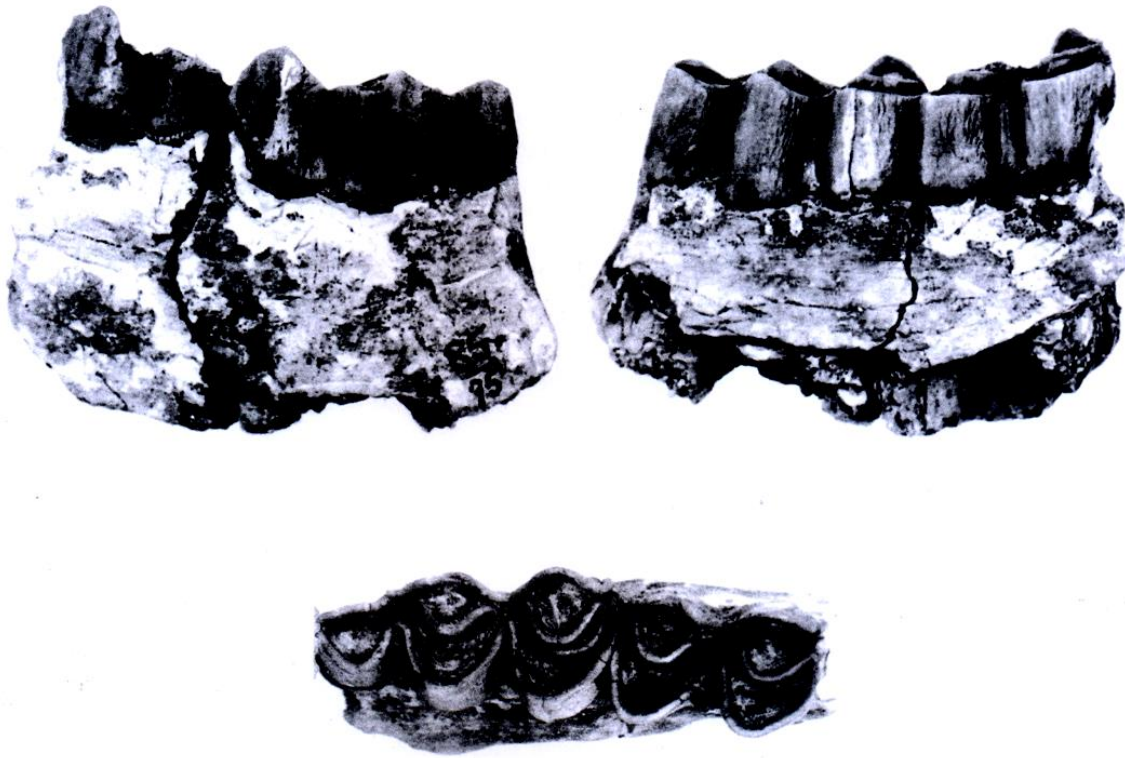


Fig. II: *Cervus sivalensis* Lydekker, a fragment of right mandible having $M_{2,3}$ (P.U.P.C. No. 85/95), collected from Hasnot, Jhelum district, the Punjab province, Pakistan. I) Lingual view, II) Buccal view, III) Crown view.

Table I: Comparative dental measurements (mm) of third lower molars referred to *Cervus sivalensis* Lydekker.

	G.S.I. No.		P.U.P.C. No.
	B215	83/641	85/95
L	35.5	55	36
W	9.4	16.5	17
W/L Index	26.5	47.14	47.2

Table II: Comparative dental measurements (mm) of second lower molars referred to *Cervus sivalensis* Lydekker.

	G.S.I. No.	P.U.P.C. No.
	B215	85/95
W	25.4	25
L	17.7	18
W/L Index	69.7	72

DISCUSSION

In *Cervus sivalensis*, the median basal pillar is quite prominent and distinct between the protocone and the hypocone. The teeth are large and quadrate in shape. The styles are moderately developed and enamel layer is rugose. The rugosity of the teeth was also pointed by Lydekker (1884). The specimens under study also indicate these features mentioned above. Lydekker (1880) mentioned the length of the tooth, which is very similar to the length of the specimens under study. M_2 is similar to M_3 except that it has no talonid. It is 25 mm long and same is the figure given by Lydekker (1880). In 1883, he stated, "In *Cervus sivalensis*, the molars had very low crown". In the material under study, the teeth are well worn and the maximum height in M_3 is 18 mm. However, Lydekker (1880) referred the type G.S.I. No. B215 to *Cervus triplidens*. and says, "The lower molars figured, may I think, possibly belong to this species". Later, in 1884, he stated, "In the original description of *Cervus triplidens* it was stated that two lower molars of a *Cervus* figured in Vol. I, pl. VIII, fig. 5, might possibly belong to that species; but it was stated in the preface to the same volume that this conjectural reference was incorrect, and the name *C. sivalensis* was proposed for the species to which the lower teeth belonged".

Pilgrim (1913) mentioned the name *C. sivalensis* in his list saying that it was from the Upper Siwaliks of Pinjor or Tatrot zone. Similarly Brown (1926) and Matthew (1929) mention this species in their account. Later Colbert (1935) described a skull and an antler under this name. The skull was collected from near Kalka, and the antler from Chandigarh. About the teeth Colbert (1935) says, "The teeth are rather badly damaged. They are large and quadrate in shape; the folds are open and the enamel rugose. The internal pillars are very small". The rugosity of the teeth was also pointed by Lydekker

(1884) who says, "The present teeth are also distinguished by the more rugose character of the enamel". In the material under study also the enamel is rugose. Matthew (1929) mentions the name of this species only in his faunal list.

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MORPHOMETRIC VARIATIONS IN TERMITE *ODONTOTERMES ASSMUTHI* HOLMGREN

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Abstract: For the study of Morphometric variations of *Odontotermes assmuthi*, samples from seven different nests, were statistically analyzed for variability. Based on Manhattan distance, the relationship among the seven population samples are given.

Key words: Termite, Imago, Soldier, Morphometric Variability, *Odontotermes assmuthi*.

INTRODUCTION

Odontotermes assmuthi Holmgren is distributed in India, Bangladesh and Pakistan. In Pakistan, it is a rare species and was collected only once from Hangu, Kohat district. This species does not construct mound in Pakistan. In Bangladesh, however, it makes mounds and has been collected from drier areas like Dinajpur and Rajshahi (Akhtar, 1975). In India, it is a serious pest of sugar cane, and also attacks timber, the bark of standing logs, etc (Roonwal, 1970).

As identification of the species of termites is based on measurements, samples from seven localities were measured for Morphometric variations. The data will serve as standard of comparison for specimens from different localities of distribution of the species and other species of the genus *Odontotermes*.

MATERIALS AND METHODS

The present study is based on the preserved material available in the collection of Prof. Dr. Muzaffar Ahmad, presently in the custody of Prof. 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 with the help of camera lucida.

Taxonomic terms and measurements used in the present study are as explained by Emerson (1945, 1952), Ahmad (1950, 1955, 1965) and Akhtar (1975). Population samples of the species collected from the geographic range of the species have been compared according to Manhattan Distance (Mayr and Ashlock, 1991) to highlight similarities and differences of the population samples.

RESULTS

Odontotermes (Odontotermes) Assmuthi: Holmgren, 1913a, Snyder, 1949; Ahmad, 1958 *Odontotermes assmuthi*: Mathur and Sen-Sarma, 1962; Akhtar, 1975; Thakur, 1981; Chhotani, 1997.

IMAGO:

The imago of *O. assmuthi* Holmgren is characterized by subcircular head capsule, minute fontanelle; area around fontanelle paler. Eyes of medium size, circular, located close to antennae, separated from lower margin of head by about 1/3 of its diameter. Ocelli separated from eyes by more than their long diameter. Pronotum trapezoidal; anterior and posterior margins substraight, anteriorly with a faint median notch, posteriorly without any emargination.

MATERIAL EXAMINED

INDIA

- A) **S. India:** Imagoes, collected by T.B. Fletcher, determined by M. Ahmad.
 B) **Pusa, Bihar:** Imagoes, determined by M. Feroz, 1.7.1952.

Intersect comparisons revealed that there were non-significant differences between samples A and B for the parameter: length of head to tip of labrum ('t' - value, 1.48; d. f., 13; $P > 0.05$); maximum width of head ('t' value, 0.50; d. f., 13; $P > 0.05$); width of postclypeus ('t'-value, 0.44; d. f., 13; $P > 0.05$); short diameter of eye ('t'-value, 1.05; d. f., 13; $P > 0.05$); long diameter of ocellus ('t'-value, 0.98; d. f., 13; $P > 0.05$); short diameter of Ocellus ('t'-value, 0.76; d. f., 13; $P > 0.05$); Ocellus from eye ('t'-value, 1.09; d. f., 13; $P > 0.05$); However, significant difference were noted for the length of head to sidebase of mandibles ('t'-value, 4.25; d.f., 13; $P < 0.001$); length of pronotum ('t'-value, 3.55; d. f., 13; $P < 0.01$); width of pronotum ('t'-value, 2.84; d. f., 13; $P < 0.01$); length of postclypeus ('t'-value, 3.04; d. f., 13; $P < 0.01$); long diameter of eye ('t'-value, 2.20; d. f., 13; $P < 0.05$); pooled data revealed maximum variability for long diameter of Ocellus ($C.V=12.36$) (Table-1).

MORPHOMETRIC VARIATIONS IN TERMITE

Table 1: INTEREST MORPHOMETRIC VARIATIONS IN TAXONOMIC PARAMETERS OF THE IMAGO CASTE OF *O. ASSMUTHI* FOLLOWED BY SIMILAR LETTER INDICATING NON-SIGNIFICANT DIFFERENCES IN MEAN VALUES BY 'T'-TEST (P>0.05)

Nest Sample	N	O.R.	X	S.D.	S.E.	95% C.I.	C.V.
Length of head to tip of labrum	A ^a	2.20-2.66	2.48	0.1802	0.0806	2.25-2.70	7.27
	B ^a	2.35-2.81	2.61	0.1603	0.0507	2.49-2.72	6.14
Length of head to side base of mandibles	A	1.38-1.53	1.46	0.0671	0.0300	1.38-1.54	4.59
	B	1.48-1.68	1.62	0.0725	0.0299	1.57-1.68	4.46
Maximum width of head	A ^a	2.09-2.30	2.23	0.1008	0.0451	2.10-2.35	4.52
	B ^a	2.09-2.35	2.25	0.0768	0.0243	2.19-2.30	3.41
Length of pronotum	A	1.02-1.07	1.03	0.0224	0.0100	1.00-1.06	2.17
	B	1.07-1.28	1.15	0.0765	0.0242	1.10-1.21	6.61
Width of pronotum	A	1.99-2.09	2.03	0.0418	0.0187	1.98-2.08	2.05
	B	2.04-2.30	2.14	0.0803	0.0254	2.08-2.20	3.75
Length of postclypeus	A	0.35-0.46	0.39	0.0455	0.0203	0.33-0.45	11.6
	B	0.40-0.51	0.45	0.0320	0.0101	0.43-0.47	7.06
Width of postclypeus	A	1.02-1.12	1.08	0.0418	0.0187	1.03-1.13	3.87
	B	1.02-1.12	1.07	0.0408	0.0129	1.04-1.10	3.81
Long diameter of eye	A	0.46-0.56	0.51	0.0354	0.0158	0.47-0.55	6.94
	B	0.51-0.56	0.52	0.0241	0.00764	0.51-0.54	4.60
Short diameter of eye	A ^a	0.40-0.51	0.46	0.0390	0.0174	0.41-0.51	8.51
	B ^a	0.46-0.51	0.47	0.02415	0.00764	0.46-0.49	5.08
Long diameter of ocellus	A ^a	0.20-0.30	0.25	0.0354	0.0158	0.21-0.29	15.6
	B ^a	0.20-0.25	0.23	0.0241	0.00764	0.22-0.25	10.2
Short diameter of ocellus	A ^a	0.15-0.20	0.19	0.0224	0.0100	0.16-0.22	11.7
	B ^a	0.15-0.20	0.18	0.026	0.0082	0.15-0.20	14.6
Ocellus from eye	A ^a	0.15-0.20	0.19	0.02191	0.00980	0.16-0.21	11.7
	B ^a	0.15-0.20	0.18	0.02582	0.00816	0.16-0.20	14.3

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;

SOLDIER

The soldier is characterized by head-capsule subrectangular, sides slightly convex, anteriorly very slightly converging at base of mandibles. Mandibles stout and short; apically weakly incurved; slightly longer than half of head-length. Left mandible with a prominent, anteriorly directed tooth a little behind apical third; postmentum subrectangular.

MATERIAL EXAMINED**Bangladesh:**

A. Rajshahi (latitude 24.25'N, longitude 88.34'E): Soldiers and workers, collected by N.K. Malik, in mound, 3.1.1970, determined by M.S. Akhtar.

B. Natore (latitude 24.24'N, longitude 88.58'E): Soldiers and workers collected by N.K. Malik, from soil, 6.1.1970, determined by M.S. Akhtar.

F. Dinajpur (latitude 25.34'N, longitude 88.35'E): Soldiers and workers, collected by N.K. Malik, from mango stump, 22.12.1969, determined by M.S. Akhtar.

India:

C. S. India: Coorg, Mercara, soldiers and workers, collected by T.B. Fletcher, determined by M. Ahmad.

D. Pusa, Bihar (latitude 25° .59'N, longitude 85° .40'E): Soldiers and workers, collected by T.B. Fletcher, swarming from nest, in ground during heavy rain, June 24, 1911, 11.6, 1913, 4.11, 1922, 1924.

G. S. India: Coorg, Mercara, Imago, soldiers and workers, collected by T.B. Fletcher and determined by M. Ahmad.

Pakistan:

E. Hangu (latitude 33.35'N, longitude 71.07'E): Soldiers and workers, from soil, ex-cow dung, collected and determined by M.S. Akhtar, 14.9.1969, 15.9.1969.

Length of Head to Sidebase of Mandibles

It varied from 1.44-1.88 mm. Seven population samples i.e., A, B, C, D, E, F and G had means 1.53, 1.47, 1.71, 1.68, 1.72, 1.54 and 1.78 mm, respectively. Coefficient of variability of seven population samples varied from 1.52-5.23 (Table II). As regards frequency distribution, the maximum number of individuals (9) measured 1.77-1.81 mm. All the measured characters were coded on this basis. For Manhattan distance data Matrix, the character states of each character were coded. On the basis of frequency distribution of specimens of the pooled data; character size range pertaining to

maximum number of individuals was coded as 1., less than said range as 1; more than said range as 2. There was significant variance component ($F.$, 18.49; $d.f.$, 6:37; $P < 0.05$) among samples collected from different localities. Specimens collected from locality G (S. India) were significantly (t -value, 8.82; $d.f.$, 10; $P < 0.001$) larger compared to those of locality B (Bangladesh: Natore). The population samples from other localities fall within the above range (Table II).

Width of Head at Sidebase of Mandibles

Width of head at Sidebase of mandibles varied from 0.72-0.94 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.75, 0.72, 0.89, 0.85, 0.84, 0.88 and 0.86 mm. respectively. Coefficient of variability of seven population samples varied from 1.58-0.53 (Table II). As regards frequency distribution, the maximum number of individuals (16) measured 0.85-0.89 mm. Again, there were significant differences ($F.$, 16.81; $d.f.$, 6:37; $P < 0.05$) amongst nest samples collected from different localities. Specimens collected from locality B (Bangladesh: Natore) were significantly (t -value, 10.76; $d.f.$, 9; $P < 0.001$) smaller compared to those of locality C (S. India). Specimens from other localities fall within the above range (Table II).

Width of Head at the Posterolateral Ends of Antennal Carinae

It varied from 0.86-1.19 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.95, 0.96, 1.12, 1.11, 1.13, 1.06 and 1.03 mm, respectively. Coefficient of variability of seven population samples varied from 1.01-5.34 (Table II). As regards frequency distribution, the maximum number of individuals (13) measured 1.11-1.15 mm. there was also significant variance component ($F.$, 15.32; $d.f.$, 6:37; $P < 0.05$) amongst nest samples collected from different localities. Specimens collected from locality e (Pakistan: Hangu) were significantly (t -value, 3.00; $d.f.$, 7; $P < 0.02$) larger compared to those of locality A (Bangladesh: Rajshahi). Specimens from other localities fall within the above range (Table II).

Maximum Width of Head

Maximum head width varied from 1.08-1.44 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 1.12, 1.13, 1.33, 1.29, 1.25, 1.16 and 1.33 mm, respectively. Coefficient of variability of seven populations varied from 1.01-5.81 (Table II). As regards frequency distribution, the maximum number of individuals (11) measured 1.13-1.17 mm. Population samples collected from different localities showed significant differences for this parameter also ($F.$, 17.12; $d.f.$, 6:37; $P < 0.05$). Specimens collected from locality A (Bangladesh: Rajshahi) were significantly (t -value, 8.15; $d.f.$, 13; $P < 0.001$) smaller compared to those of locality G (S. India). The remaining population samples fall within the above range (Table II).

Length of Left Mandible

It varied from 0.82-1.00 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.85, 0.84, 0.92, 0.91, 0.92, 0.87 and 0.97 mm, respectively. Coefficient of variability of seven population samples varied from 1.24-4.15. As regards frequency distribution, the maximum number of individuals (16) measured 0.92-0.96 mm.

Analyses of variance revealed significant differences (F., 15.49; d.f., 6:37; $P < 0.05$) amongst nest samples collected from different localities. Specimens collected from locality G (S. India) were significantly ('t'-value, 11.21; d.f., 10; $P < 0.001$) larger compared to those of locality B (Bangladesh: Natore). The remaining population samples fall within the above range (Table II).

Tooth of Left Mandible from Tip

It varied from 0.28-0.36 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.30, 0.31, 0.32, 0.32, 0.34, 0.32 and 0.32 mm, respectively. Coefficient of variability of seven population samples varied from 3.50-8.31 (Table II). As regards frequency distribution, the maximum number of individuals (27) measured 0.28-0.32 mm. There was no significant variance component (F., 0.83; d.f., 6:37; $P > 0.05$) amongst nest samples collected from different localities. However, for this parameter, specimens collected from locality A (Bangladesh: Rajshahi). The remaining population samples fall within the above range (Table II).

Length of Pronotum

It varied from 0.41-0.64 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.45, 0.42, 0.49, 0.48, 0.49, 0.51 and 0.59 mm, respectively. Coefficient of variability of seven population samples varied from 2.32-6.29 (Table II). As regards frequency distribution, the maximum number of individuals (20) measured 0.46-0.50 mm. Samples collected from different localities showed significant variance component (F., 40.21; d.f., 6:37; $P < 0.05$) for this parameter. Specimens collected from locality G (S. India) were significantly ('t'-value, 7.62; d.f., 10; $P < 0.001$) larger compared to those of locality B (Bangladesh: Natore). The population samples from other localities fall within the above range (Table II).

Width of Pronotum

Width of pronotum varied from 0.78-1.03 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.83, 0.93, 0.97, 0.88, 0.85, 0.85 and 0.98 mm, respectively. Coefficient of variability of seven population samples varied from 1.04-6.54 (Table II). As regards frequency distribution, the maximum number of individuals (12) measured 0.83-0.87 mm. Again, there was significant variance component (F., 17.43; d.f., 6:37 $P < 0.05$) amongst nest samples collected from different localities. Specimens collected from locality G (S. India) were significantly ('t'-value, 7.22; d.f., 13; $P < 0.001$) larger compared to those of locality A (Bangladesh: Rajshahi). The remaining population samples fall within the above range (Table II).

Length of Postmentum

It varied from 0.88-1.15 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.99, 0.93, 1.09, 1.02, 1.08, 1.06 and 1.04 mm, respectively. Coefficient of variability of seven population samples varied from 1.91-6.54 (Table II). As regards frequency distribution, the maximum number of individuals (19) measured 1.02-1.06 mm. Samples collected from different localities showed significant variance component for this parameter (F., 6.76; d.f., 6:37; $P < 0.05$). Specimens collected from

locality C (S. India) were significantly larger (t -value, 4.76; d.f., 9; $P < 0.05$) compared to those of locality B (Bangladesh: Natore). Samples collected from other localities fall within the above range (Table II).

Width of Postmentum

Width of postmentum varied from 0.45-0.54 mm. Seven population samples i.e., A, B, C, D, E, F and G have mean values 0.45, 0.45, 0.48, 0.48, 0.48, 0.45 and 0.51 mm, respectively. Coefficient of variability of seven population samples varied from 1.80-4.52 (Table II). As regards frequency distribution, the maximum number of individuals (31) measured 0.45-0.49 mm. there was significant variance component (F , 9.89; d.f., 6:37; $P < 0.05$) among samples collected from different localities. Specimens collected from locality F (Bangladesh: Dinajpur) were smaller compared to those of locality G (S. India). The remaining population samples fall within the above range (Table II).

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

Nest Sample	N	O.R.	X	S.D.	S.E.	95% C.I.	C.V.
Length of head to side base of mandibles							
A ^a	6	1.50-1.56	1.53667	0.02338	0.00955	1.51212-1.56121	1.52
B ^b	3	1.44-1.52	1.4733	0.0416	0.0240	1.3699-1.5768	2.82
C ^d	8	1.64-1.77	1.7138	0.0398	0.0176	1.6721-1.7554	2.90
D ^{cd}	10	1.60-1.79	1.6860	0.0836	0.0264	1.6262-1.7458	4.95
E ^{cd}	3	1.66-1.79	1.7267	0.0651	0.0376	1.5650-1.8883	3.77
F ^{ab}	5	1.47-1.65	1.5480	0.0811	0.0362	1.4473-1.6487	5.23
G ^e	9	1.70-1.88	1.7822	0.0549	0.0183	1.7400-1.8245	3.08
F., 18.49; d.f., 6:37; P<0.05							
Width of head at side base of mandibles							
A ^a	6	0.72-0.80	0.7533	0.0273	0.0112	0.7246-0.7820	3.62
B ^a	3	0.72-0.74	0.72667	0.01155	0.00667	0.69798-0.75535	1.58
C ^c	8	0.88-0.94	0.89000	0.02619	0.00926	0.86810-0.91190	2.94
D ^d	10	0.80-0.92	0.8500	0.0403	0.0127	0.8212-0.8788	4.74
E ^{cd}	3	0.80-0.88	0.8467	0.0416	0.0240	0.7432-0.9501	4.91
F ^{cd}	5	0.87-0.90	0.88200	0.01643	0.00735	0.86159-0.90241	1.86
G ^{cd}	9	0.79-0.90	0.8600	0.0433	0.0144	0.8267-0.8933	5.03
F., 16.81; d.f., 6:37; P<0.05							
Width of head at the Postscroteral ends of antennal carinae							
A ^a	6	0.86-0.98	0.9500	0.0452	0.0184	0.9026-0.9974	4.75
B ^a	3	0.94-0.98	0.9600	0.0200	0.0115	0.9103-1.0097	2.08
C ^c	8	1.03-1.17	1.1225	0.0512	0.0181	1.0797-1.1653	4.56
D ^d	10	1.03-1.19	1.1160	0.0470	0.0148	1.0824-1.1496	4.21
E ^{cd}	3	1.13-1.15	1.13667	0.01155	0.00667	1.10798-1.16535	1.01
F ^f	5	1.05-1.10	1.0600	0.0224	0.0100	1.0322-1.0878	2.11
G ^f	9	0.92-1.13	1.0344	0.0553	0.0184	0.9920-1.0769	5.34
F., 15.32; d.f., 6:37; P<0.05							
Maximum width of head							
A ^a	6	1.08-1.17	1.1250	0.0321	0.0131	1.0913-1.1587	2.85
B ^{ab}	3	1.13-1.15	1.13667	0.01155	0.00667	1.10798-1.16535	1.01
C ^c	8	1.19-1.44	1.3300	0.0773	0.0273	1.2654-1.3946	5.81
D ^{cd}	10	1.99-1.35	1.2900	0.0533	0.0169	1.2518-1.3282	4.13
E ^{cd}	3	1.23-1.29	1.2500	0.0346	0.0200	1.1639-1.3361	2.76
F ^{ab}	5	1.13-1.23	1.1660	0.0385	0.0172	1.1182-1.2138	3.30
G ^{cd}	9	1.29-1.41	1.3367	0.0574	0.0191	1.2925-1.3808	4.29
F., 17.21; d.f., 6:37; P<0.05							

MORPHOMETRIC VARIATIONS IN TERMITE

Length of left mandible									
A ^a	6	0.82-0.88	0.85667	0.02338	0.00955	0.83212-0.88121	2.72		
B ^{ab}	3	0.84-0.86	0.84667	0.01155	0.00667	0.81798-0.87335	1.36		
C ^c	8	0.88-0.98	0.9275	0.0385	0.0136	0.8953-0.9597	4.15		
D ^{cd}	10	0.86-0.96	0.9120	0.0355	0.0112	0.8866-0.9374	3.89		
E ^{cd}	3	0.92-0.94	0.92667	0.01155	0.00667	0.89798-0.95535	1.24		
F ^{ab}	5	0.84-0.90	0.8720	0.0228	0.0102	0.8437-0.9003	2.61		
G	9	0.95-1.00	0.97222	0.01787	0.00596	0.95848-0.98596	1.83		
F., 15.49; d.f., 6:37; P<0.05									
Tooth of left mandible from tip									
A	6	0.28-0.35	0.30833	0.02401	0.00980	0.28313-0.33354	7.78		
B	3	0.30-0.32	0.31200	0.01095	0.00490	0.29839-0.32561	3.50		
C	8	0.30-0.35	0.32625	0.02134	0.00754	0.30841-0.34409	6.54		
D	10	0.30-0.35	0.32600	0.02675	0.00846	0.30686-0.34514	8.20		
E	3	0.32-0.35	0.3400	0.0173	0.0100	0.2970-0.3830	5.08		
F	5	0.32-0.35	0.32600	0.01342	0.00600	0.30934-0.34266	4.11		
G	9	0.28-0.36	0.32444	0.02698	0.00899	0.30370-0.34519	8.31		
F., 0.83; d.f., 6:37; P>0.05									
Length of pronotum									
A	6	0.43-0.47	0.45333	0.01506	0.00615	0.43753-0.46914	3.32		
B	3	0.41-0.43	0.42333	0.01155	0.00667	0.39465-0.45202	2.72		
C ^c	8	0.47-0.51	0.49500	0.01414	0.00500	0.48317-0.50683	2.85		
D ^d	10	0.45-0.49	0.48000	0.01414	0.00447	0.46988-0.49012	2.94		
E ^{cd}	3	0.49-0.51	0.49667	0.01155	0.00667	0.46798-0.52535	2.32		
F ^{cc}	5	0.50-0.55	0.51400	0.02191	0.00980	0.48679-0.54121	4.26		
G	9	0.56-0.64	0.5956	0.0375	0.0125	0.5668-0.6244	6.29		
F., 40.21; d.f., 6:37; P<0.05									
Width of pronotum									
A ^a	6	0.78-0.86	0.8300	0.0303	0.0124	0.7982-0.8618	3.65		
B ^b	3	0.88-1.00	0.9333	0.0611	0.0353	0.7815-1.0851	6.54		
C ^{bc}	8	0.94-1.03	0.9725	0.0396	0.0140	0.9394-1.0056	4.07		
D ^{cd}	10	0.82-0.92	0.8818	0.0424	0.0128	0.8533-0.9103	4.53		
E ^{cd}	3	0.85-0.87	0.85667	0.01155	0.00667	0.82798-0.88335	1.34		
F ^{cd}	5	0.85-0.87	0.85400	0.00894	0.00400	0.84289-0.86511	1.04		
G ^{cd}	9	0.92-1.03	0.9800	0.0442	0.0147	0.9460-1.0140	4.51		
F., 17.43; d.f., 6:37; P<0.05									

Length of Postmentum									
A ^a	6	0.94-1.03	0.9900	0.0369	0.0151	0.9513-1.0287	3.72		
B ^{ab}	3	0.88-1.00	0.9333	0.0611	0.0353	0.7815-1.0851	6.54		
C ^c	8	1.03-1.15	1.0987	0.0482	0.0171	1.0584-1.1391	4.38		
D ^{cd}	10	0.92-1.13	1.0260	0.0672	0.0212	0.9779-1.0741	6.54		
E ^{cd}	3	1.07-1.11	1.0867	0.0208	0.0120	1.0350-1.1384	1.91		
F ^{cd}	5	1.05-1.12	1.0640	0.0313	0.0140	1.0251-1.1029	2.94		
G ^{cd}	9	1.03-1.10	1.04000	0.02345	0.00782	1.02197-1.0583	2.25		
F., 6.76; d.f.:6:37; P<0.05									
Width of postmentum									
A ^a	6	0.45-0.47	0.45333	0.00816	0.00333	0.44476-0.46190	1.80		
B ^{ab}	3	0.45-0.47	0.45667	0.1155	0.00667	0.42798-0.48535	2.52		
C ^c	8	0.47-0.51	0.48500	0.01773	0.00627	0.47017-0.49983	3.65		
D ^{cd}	10	0.47-0.51	0.48400	0.02119	0.00670	0.46884-0.49916	4.37		
E ^{cd}	3	0.47-0.51	0.4833	0.0231	0.0133	0.4260-0.5407	4.37		
F ^{cd}	5	0.45-	0.45000	0.00000	0.00000	0.45000-0.45000	4.37		
G ^{cd}	9	0.46-0.54	0.51111	0.02315	0.00772	0.49331-0.52891	4.52		
F., 9.86; d.f.:6:37; P<0.05									

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

Parameters	N	Q.R.	X	S.D.	S.E.	95% C.I.	C.V
Length of head to side base of mandibles	44	1.44-1.88	1.6627	0.1160	0.0175	1.6275-1.6980	6.97
Width of head at side base of mandible	44	0.72-0.94	0.84341	0.06206	0.00936	0.82454-0.86228	7.35
Width of head at the Posterolateral end of antennal carinae	44	0.86-1.19	1.0657	0.0774	0.0117	1.0421-1.08692	7.26
Maximum width of head	44	1.08-1.44	1.2570	0.0974	0.0147	1.2274-1.2867	7.74
Length of left mandible Tooth of left mandible from tip	44	0.82-1.00	0.91159	0.05681	0.00856	0.89431-0.92887	6.23
Length of pronotum	44	0.28-0.36	0.32409	0.02326	0.00351	0.31702-0.33116	7.17
Width of pronotum	44	0.41-0.64	0.50432	0.05609	0.00846	0.48726-0.52137	11.1
Length of postmentum	44	0.78-1.03	0.9073	0.0812	0.0122	0.8826-0.9320	8.94
Width of postmentum	44	0.88-1.15	1.03932	0.06259	0.00944	1.02028-1.05835	6.02
	44	0.45-0.54	0.47977	0.02715	0.00409	0.47152-0.48803	5.65

INDICES**i) Mandibular Tooth Index (TLT/LLM)**

The index value varied from 0.29-0.41. The mean values were 0.35, 0.36, 0.34, 0.36, 0.37, 0.37 and 0.34 for samples A, B, C, D, E, F and G, respectively (Map). Sample from locality G (S. India) has the highest value of coefficient of variability (C.V.=8.67) (Table IV).

ii) Head Mandibular Index (LLM/LHSBM)

The index value varied from 0.51-0.60. The mean values were 0.55, 0.58, 0.56, 0.53, 0.57, 0.56 and 0.54 for samples A, B, C, D, E, F and G, respectively (Map). Sample from locality F (Pakistan: Hangu) has the highest value of coefficient of variability (C.V.=4.46) for this index (Table IV)

iii) Head Width Mandibular Index (LLM/MWH)

The index value varied from 0.67-0.80. The mean values were 0.76, 0.74, 0.72, 0.74, 0.75, 0.75 and 0.72 for samples A, B, C, D, E, F and G, respectively (Map). Sample from locality C (S.India) has the highest value of coefficient of variability (C.V.=5.09) for this index (Table IV). The mean value indices are indicated in Map.

Cluster Analysis

On the basis of Manhattan distance, specimens from locality A (Bangladesh: Rajshahi) and B (Bangladesh: Natore) from primary cluster at value of 2, specimens from locality C (S. India) and E (Pakistan:Hangu) from another primary cluster at value of 3. Sample D (India : Puna, Bihar) and F (Bangladesh : Dinajpur) from third primary cluster at value of 4. Pairs CE and DF join to form secondary cluster at value of 6.5. Pair AB joins CEDF at value of 6.75. Sample G (S. India) joins CEABDE at value of 7.83 to form tertiary cluster (Fig.1). (Table V to VI).

DISCUSSION

The distance of tooth from tip of left mandible is a very important character for distinguishing different species in the Genus *Odontotermes* and it varied from 0.28-0.36 mm in the pooled data (Table III), showing overlapping in most of the samples. Highest tooth distance was recorded for specimens from locality E (Pakistan:Hangu) and lowest for specimens from locality A(Bangladesh:Rajshahi). Pooled data also revealed that samples were more variable for length of pronotum (C.V.=11.1)(Table III). Thakur (1981) and Chhotani (1997) have reported length of pronotum as 0.48-0.58 mm. In the present report the length of pronotum ranged from 0.41-0.64 mm. Specimens from

locality G (S. India) collected by Fletcher and determined by Ahmad are the largest Cluster analysis also reveals that specimens from locality G (S. India) are distantly related to others (Fig. 1).

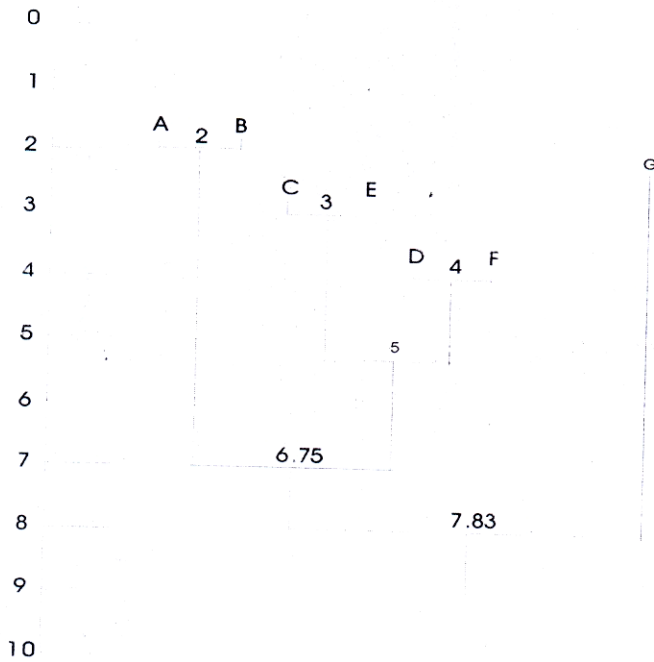


Fig. 1: Phenogram: Manhattan distance of the soldier samples of *O. assmuthi* Holmgren. Primary clusters are indicated by solid lines, secondary clusters by dotted lines and tertiary clusters by dashed lines. The scale on the left is a distance measure.

Table IV: Statistics of various indices used in this study for *O. assmuthi* Holmgren.

Nest Sample	Mandibular Tooth Index (TL/T/LLM)	N	O.R.	X	S.D.	S.E.	95% C.I		C.V
							Average mean value = 0.35		
i) A	0.32-0.41	6	0.35	0.028136571	0.011486707	0.33-0.37	8.03		
B	0.35-0.38	3	0.36	0.014142135	0.008164965	0.34-0.38	3.92		
C	0.31-0.36	8	0.34	0.021758618	0.007692833	0.32-0.35	6.39		
D	0.34-0.40	10	0.36	0.025865034	0.008179242	0.34-0.38	7.18		
E	0.36-0.39	3	0.37	0.012472191	0.007200823	0.35-0.38	3.37		
F	0.35-0.40	5	0.37	0.01720465	0.007694153	0.35-0.38	4.64		
G	0.29-0.37	9	0.34	0.02949	0.00983	0.32-0.36	8.67		
							* Average mean value = 0.35		
ii) A	0.53-0.56	6	0.55	0.012133516	0.004953487	0.54-0.56	2.20		
B	0.56-0.60	3	0.58	0.016996731	0.009813067	0.56-0.60	2.93		
C	0.54-0.58	8	0.56	0.015162495	0.00551985	0.55-0.57	2.78		
D	0.51-0.57	10	0.53	0.021071307	0.006663332	0.52-0.54	3.97		
E	0.55-0.60	3	0.57	0.020548046	0.01186342	0.55-0.59	3.60		
F	0.53-0.59	5	0.56	0.024979991	0.011171392	0.54-0.58	4.46		
G	0.53-0.58	9	0.54	0.01922	0.00641	0.53-0.56	3.55		
							* Average mean value = 0.55		
iii) A	0.72-0.80	6	0.76	0.026718699	0.010907863	0.74-0.78	3.51		
B	0.73-0.76	3	0.74	0.012472191	0.007200823	0.725-0.75	1.68		
C	0.67-0.79	8	0.72	0.036657195	0.012960275	0.69-0.74	5.09		
D	0.71-0.78	10	0.74	0.032572994	0.010300485	0.72-0.76	4.40		
E	0.71-0.80	3	0.75	0.03681787	0.021256807	0.71-0.79	4.90		
F	0.72-0.78	5	0.75	0.021354156	0.009549869	0.73-0.77	2.84		
G	0.69-0.77	9	0.72	0.02651	0.00884	0.70-0.74	3.68		
							* Average mean value = 0.74		

Table V: Data Matrix:

Parameters	A	B	C	D	E	F	G
Length of head to side base of mandibles (1.77-1.81)=1 Less than this range =0 More than this range =2	0	0	0	0	0	0	0
Width of head at side base of mandibles (0.85-0.89)=1 Less than this range =0 More than this range =2	0	0	1	1	1	1	1
Width of head at the Posterolateral ends of antennal carinae (1.11-1.15)=1 Less than this range =0 More than this range =2	0	0	1	1	1	0	0
Maximum width of head (1.13-1.17)=1 Less than this range =0 More than this range =2	0	1	2	2	2	1	2
Length of left mandible (0.92-0.96)=1 Less than this range =0 More than this range =2	0	0	1	0	1	0	2
Tooth of left mandible from tip (0.28-0.32)=1 Less than this range =0 More than this range =2	1	1	1	1	2	1	1
Length of pronotum (0.46-0.50)=1 Less than this range =0 More than this range =2	0	0	1	1	1	2	2
Width of pronotum (0.83-0.87)=1 Less than this range =0 More than this range =2	1	2	2	2	1	1	2
Length of postmentum (1.02-1.06)=1 Less than this range =0 More than this range =2	0	0	2	1	2	1	1
Width of postmentum (0.45-0.49)=1 Less than this range =0 More than this range =2	1	1	1	1	1	1	2

Table VI: Similarity Matrix: Manhattan distance

		Taxa						
	A	B	C	D	E	F	G	
A		2	9	7	8	5	11	
B	X		7	5	8	5	9	
C	2	X		2	3	6	6	
D	9	7	X		5	4	6	
E	7	5	2	X		7	9	
F	8	8	3	5	X		6	
G	5	5	6	4	7	X		
	11	9	6	6	9	6	X	

Table VII: Similarly Matrix: Manhattan distance ranged by similarity

		Taxa						
	A	B	C	D	E	F	G	
A		3	2	6	6	7	9	
B	X		5	7	9	8	8	
C	3	X		4	6	5	7	
D	2	5	X		6	5	5	
E	6	7	4	X		9	11	
F	6	9	6	6	X		2	
G	7	8	5	5	9	X		
	9	8	7	5	11	2	X	

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