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PRELIMINARY PETROGRAPHIC INVESTIGATION OF COPPER MINERALISATION IN THE TECTONISED PERIDOTITES OF KWATHA VILLAGE, CHANDEL DISTRICT, MANIPUR

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Abstract

The Cu- bearing tectonised peridotites from the study area have been preliminarily investigated for their petrographic properties. The Cu- bearing mineral is mainly represented by malachite. It occurs as thin vein. In plane polarized light malachite shows bluish to greenish grey in colour. Chalcopyrite occurs rarely in some samples. The present investigation shows that malachite replaced silicates partially. It supports that the copper mineralization took place at late stage. In all the samples, the irons in the forms of magnetite,martite and goethite content are much more than copper minerals. In the present context, the copper minerals available in the study area are not economic one but are units of ophiolitc mineral assemblages. Detail studies are required along this ophiolite suite/belt to locate more copper deposits.

Key words : Peridotites, copper ore, Manipur Ophiolitic Complex, NE India.

INTRODUCTION

The Geological chapter in the Naga-Manipur ophiolitic Belt (NMOB) of Northeast India has been opened with the reconnaissance field work of Theobald (1873), Mallet (1876), Oldham(1883), Pascoe (1912) and Evans (1932). During past five decades intensive geological*Blinded Manuscript investigations and systematic mapping in different parts of the region (Mathur and Evans, 1964;Karunakaran et al., 1964; Brunnschweiler, 1966; Sriram and Mukhopadhayay, 1971; Gansser,1980; Mitchell, 1981; Singh and Ghose, 1981; Chattopadhyay et al., 1983; Acharyya et al., 1989;Anon, 1986; Nandy, 1984, Venkataramana et al., 1986; Sengupta et al., 1989; Mitra

et al., 1986;Agrawal and Ghose, 1986; Ghosal, 1986; Ghose et al., 1986; Venkataramana and Bhattacharyya,1989; Bhattacharjee, 1991; Acharyya, 2007) have established the stratigraphy and tectonic setting based on the petrological and geochemical studies of ophiolitic suite of rocks emphasizing those occurring in the Nagaland Ophiolitic Complex. However, a limited data is available on the mineralogy and geochemistry of the ophiolite suite of rocks from the Manipur OphioliticComplex (MOC) (Fig.1) (Venkataramana, 1985; Mitra et al., 1986; Ghose and Shrivastava, 1986; Vidyadharan et al., 1989; Gupta et al., 1995; Singh et al., 2008; Singh, 2008; Singh, 2009; Singh et al., 2010; Ningthoujam et al., 2012). The purpose of the present paper is to provide field data,petrographical characteristics and preliminary petrological data of the copper ores in the serpentinised peridotites from the southern part of MOC in order to discuss their mode of mineralization..

GEOLOGICAL SETTING

The NMOB extending from Nagaland in the north to Manipur in the south forms a part of the Indo-Myanmar Orogenic Belt (IMOB). It is a narrow belt trending NNE-SW, ~2-20 km in width, covers an area ~2000 sq. km. Further south in structural continuity of this belt, theAndaman and Nicobar Islands Arc has formed and the belt continues further southeast to theMentawai Islands representing the outer Indonesian Island Arc (Van Bemmelen, 1970; Moore et al., 1980). The IMOB is interpreted as representing the eastern suture of Indian plate and it was formed due to the collision of the Indian plate with the Myanmar plate (Gansser, 1980; Mitchel,1981; Acharyya et al., 1989; Bhattacharjee, 1991). The ophiolite sequence in this region is highly tectonised, dismembered and shows three phases of deformational events broadly comparable to the Himalayan orogeny and sea floor spreading of the Indian Ocean (Ghose et al., 1986). This ophiolite was generated during the beginning of spreading of ocean basin, which escaped reequilibration and significant fractionation developed at the edge of ocean basin adjacent to continental margins (Vidyadharan et al., 1989). Roy (1989) has described the Ophiolite as rootless and provided evidence of oceanic crust, which was generated mainly through a relatively fast spreading mechanism and some occasional off-ridge volcanic centers, emplaced following the subduction of Indian plate beneath the Myanmar plate. Acharyya et al. (1990) also reported that this ophiolite is represented by dismembered mafic and ultramafic rocks which are closely associated with oceanic pelagic sediments and occur as folded thrust slices occupying the highest tectonic levels and are brought to lie over distal shelf sediments of Eocene to Oligocene age. This ophiolitic complex is haphazardly juxtaposed along faults or they consist of lensoid slices interbedded with the Disang Group of rocks. The lower Disang sediments were intermixed with pelagic

cherts and limestone (Bhattacharjee, 1991). The Olistolith bodies trending NE-SW and NNE-SSW in the area has been assigned Middle Eocene to Palaeocene age (Mitra et al., 1986). Singh (1992) identified microfacies in carbonate rocks as fossiliferous micrite, sparse biomicrite and packed biomicrite. Close association of carbonates with the pelagic sediments suggests deposition above carbonate-compensation-depth (Acharyya et al., 1989). Based on the whole rock chemistry and mineral chemistry of the Al-rich Cr-Spinels, it has suggested that host peridotites of the Naga-Manipur ophiolites have an affinity to abyssal and alpine-type peridotites and these peridotites might have been derived from tholeiitic melt at low degree of partial melting in a mid oceanic ridge setting (Singh, 2009; Singh et al., 2010; Ningthoujam et al., 2012). On the basis of faunal assemblages (radiolarian, nannococoliths and planktonic foraminifera), the Naga-Manipur ophiolites has been assigned to range in age from Cretaceous to Paleocene (Chattopadhyay et al. 1983; Acharyya et al., 1986; Chungkham and Jafar, 1998). The presence of rare arenaceous and benthic foraminifera, plant fragments and Ophiomorpha-type burrow structures in the Disang and Barail formations indicate that these rocks were deposited in a shallow marine to deltaic setting (Acharyya et al., 1986). Shallow marine environment of the area is also supported by the presence of pillow lava (Singh and Ghose 1981; Agrawal and Ghose 1986; Venkataramana et al., 1986; Singh et al., 2008).

In the present study area, serpentinised peridotites (viz. harzburgite, lherzolite and wehrlite) are closely associated with the pelagic sediments (cherts, greywackes, limestones and shales) and podiform chromitite. Harzburgite is the most dominant rock type among the ultramafics. Small-scale irregular joints are also developed in the rocks with the presence of slickenside and striations.. The resistant minerals of pyroxene show "hob nail" structure on weathering. Lherzolite is characterized by greenish black to dark green colour, medium grained nature with conchoidal fracture and shows moderate degree of serpentinisation.. Wehrlite is rare greenish black in colour and medium grained. Deformation lamellae are often observed with corroded margins of different shapes and sizes. Minor formation of asbestos is occasionally observed in peridotites. The distribution of chromitites in the area is irregular and the exact nature of the chromitite with the associated host rocks could not be ascertained due to high degree of alteration. However, at places, chromitites are well associated with peridotites in situ and pods of chromitite within the rock are also recorded. Based on texture and mode of occurrence various types of chromitites, e.g., massive, disseminated, granular andnodular has been identified in the field established (Ghose and Shrivastava, 1986, Singh, 2008).

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A few basaltic dykes are also intruded within the peridotites. The generalized geological Succession of study area is given in Table 1.

Table 1 : Geological succession of the study area.

Age	Group	Lithological characters
Eocene	Disangs	Grey dark splintery shale with flaggy sandstone
Eocene	Oceanic pelagic sediments	Cherts, greywackes, shales, limestones, etc.
----------	Tectonic Contact	----------
Eocene to Cretaceous	Ophiolite Suite	Peridotites, serpentinites, basalt, plagiogranite
----------	Tectonic Contact	----------
?	Metamorphites	Quartzite, phyllite, slate

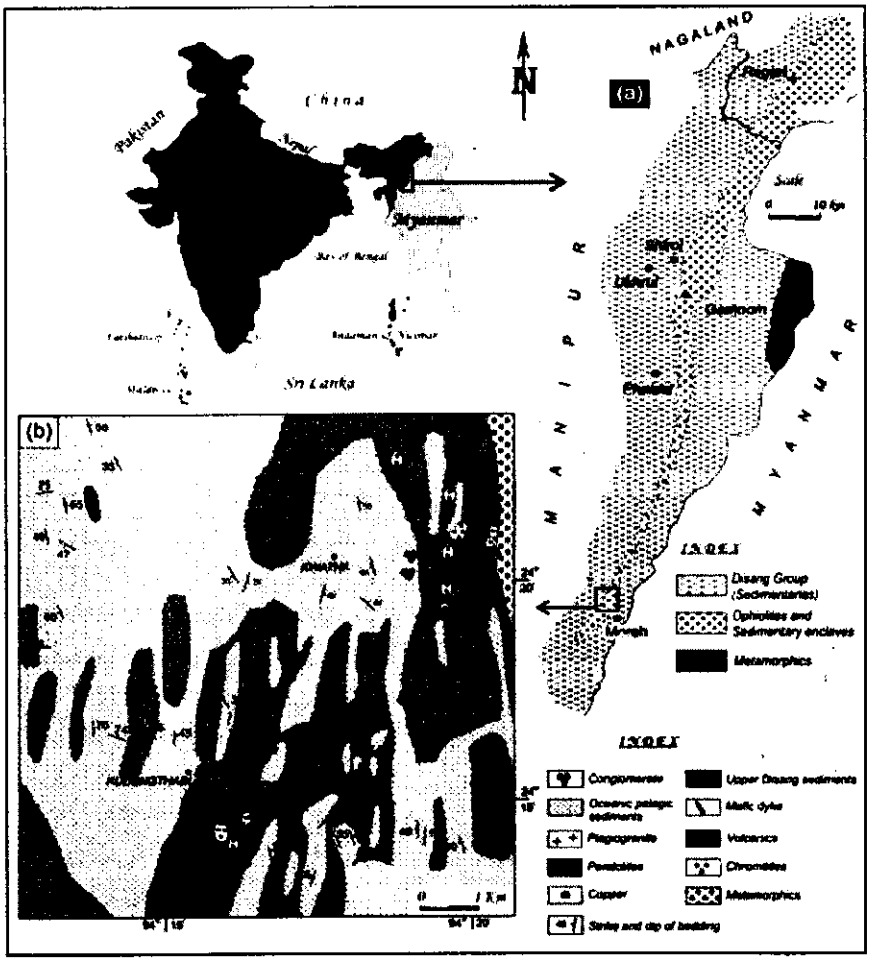

Fig. 1: Location and Geological Map of the study area.

Petrography of the Cu-bearing rocks from Manipur Ophiolite

The Cu-bearing rocks from the ophiolite suite of Manipur were studied under an optical petrological microscope (Leitz/Leica Orthoplan) using reflected polarized light. Conventionally prepared polished mounts of all ten samples were investigated. It was found that in these rocks the Cu-bearing mineral is mainly represented by malachite which is a hydrated carbonate of copper. Malachite occurs mostly as thin veins from a millimeter thickness down up to micron levels. In some instances it replaces the associated silicates. Malachite shows a bluish to greenish grey color in plane polarized light. Under crossed nicols it shows distinct internal reflections. Occurrence of chalcopyrite has been recorded only rarely. In sample number 5, it occurs associated with magnetite. The overall abundance of copper minerals is very low (~5 modal %). However, the samples contain lots of iron oxides in form of magnetite, martite and goethite.

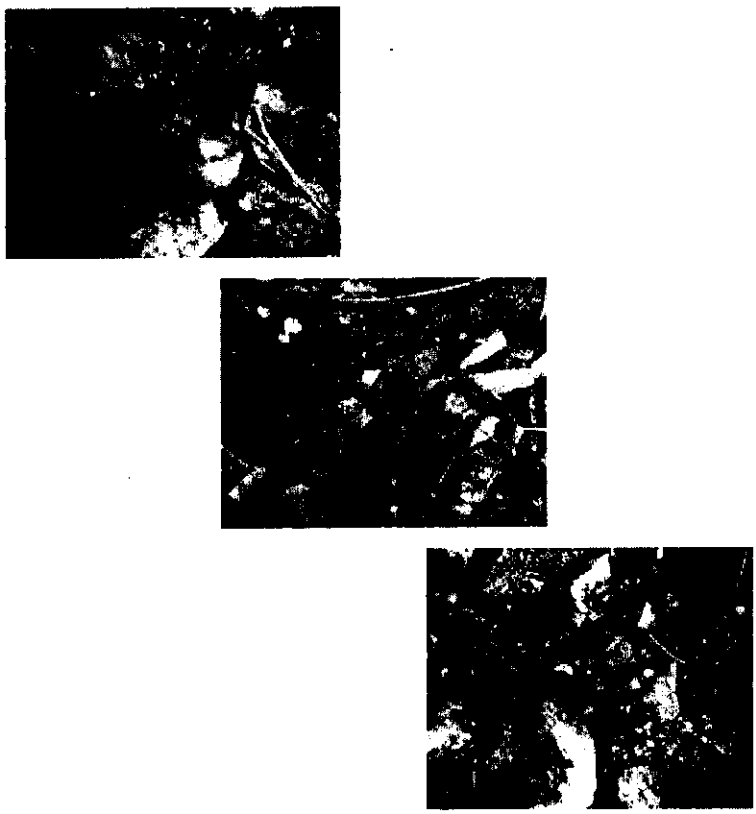

Fig. 2 : Copper mineralization in the tectonised peridotites, study area.

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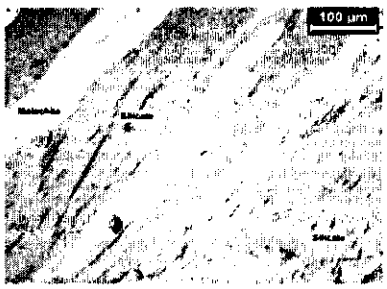
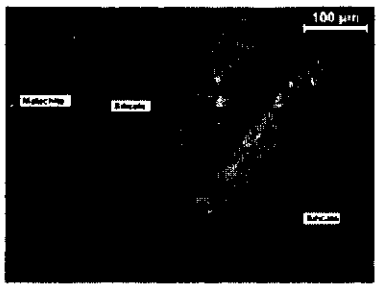
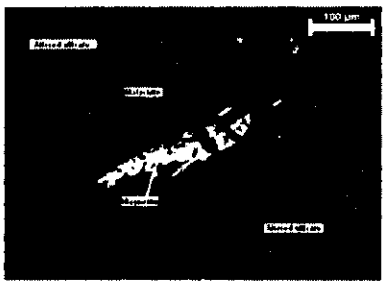
The abundance of iron minerals is much more than the copper minerals. Magnetite occurs in granular form and in clusters. At many instances, the magnetite alters to martite (hematite) from grain boundaries and weak planes. Most of the samples have suffered alteration and partial weathering which is evidenced by goethite/jarosite veins. The petrographic characters of these Cu-bearing rocks are described in the following figures.



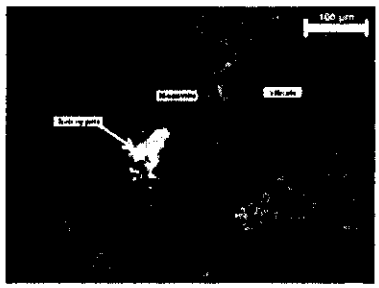
(1) Parallel veins of malachite traversing through the silicates. Plane polarized light.



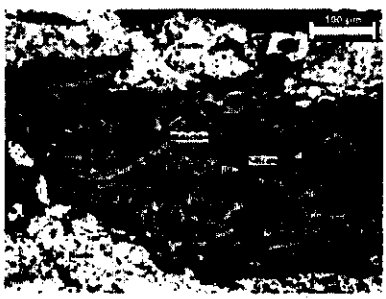
(2) The same image as in (1) under crossed nicols. Note the internal reflections in malachite.



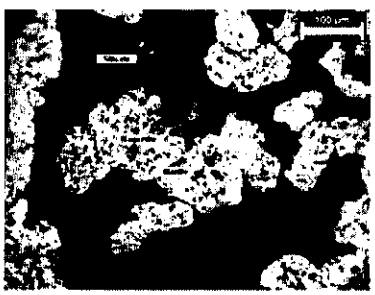
(3) Crystallized malachite in form of veins enclosing magnetite in a matrix of altered silicates. Plane polarized light.



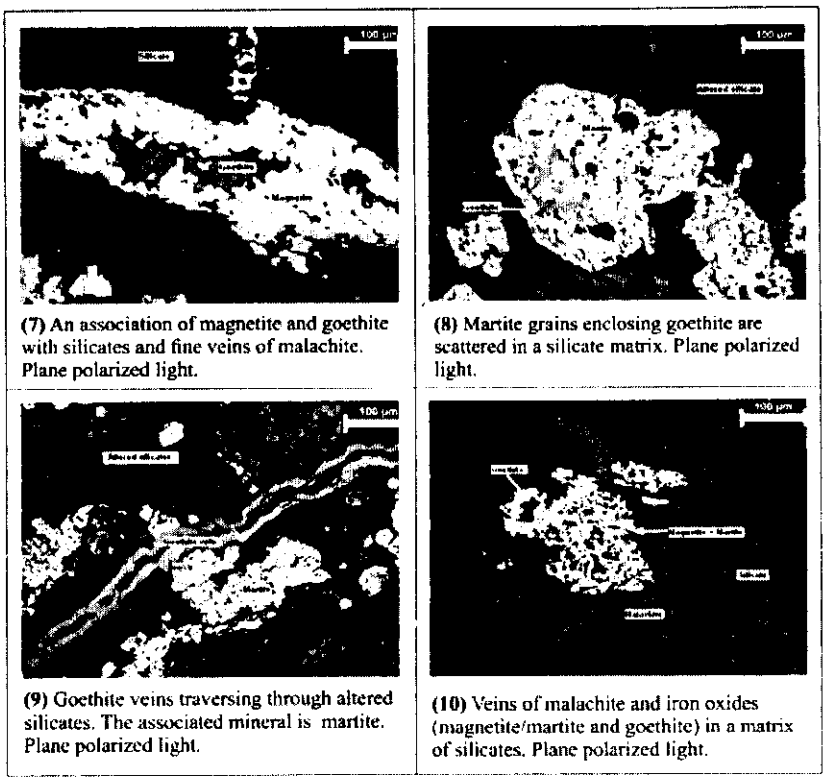
(4) Chalcopyrite associated with magnetite in a base of silicates. Crossed nicols.



(5) Malachite replacing silicates. The magnetite grains have been converted to martite, . Plane polarized light.



(6) Granular magnetite crystals (dispersed in a silicate matrix) are partially converted to martite. Plane polarized light.



(7) An association of magnetite and goethite with silicates and fine veins of malachite. Plane polarized light.

(8) Martite grains enclosing goethite are scattered in a silicate matrix. Plane polarized light.

(9) Goethite veins traversing through altered silicates. The associated mineral is martite. Plane polarized light.

(10) Veins of malachite and iron oxides (magnetite/martite and goethite) in a matrix of silicates. Plane polarized light.

Fig.3. Microscopic photographs of the Cu-bearing tectonised peridotites, study area.

DISCUSSION AND CONCLUSION

The area under investigation consists chiefly of peridotites showing varying degrees of serpentinisation and minor amount of mafic and acidic rocks. They are dismembered and variously sheared-and brecciated and occur under Disang sediments. The lithounits belonging to peridotites are harzburgite, lherzolite and wehrlite. The partial complete serpentinisation is widespread in most of the olivine rich rocks. Serpentinisation is a low temperature process unrelated to the petrogenesis of the primary mineral assemblage. This indicates the experience of metamorphism by the tectonised peridotites (Coleman, 1977). Based on the whole rock chemistry and mineral chemistry of the all rich Cr-spinels, it has been sugested that the host Cu- bearing tectonised peridotites of Nagaland- Manipur ophiolites have an affinity to abyssal and alpine-type peridotites and these peridotites might have been derived from tholeiitic melt at low degree of partial melting in a mid-oceanic ridge setting (Singh,2009;Singh et al., 2010; Ningthoujam et al.,2012).

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The oxide and sulphide ore minerals present in the tectonised peridotites of study area are chromite, copper and iron ores. The petrographic investigation of Cu-bearing rocks of the study area is based on microscopic characters using reflected polarized light. The malachite occurs as thin vein whereas the chalcopyrite occurs as segregated type in the ground mass of altered silicates (pyroxenes). The malachite shows a bluish to greenish grey colour in plane polarized light with internal reflection in malachite under crossed nicol as shown in Fig.3:2. In Fig.3:3, the magnetite is enclosed by crystallized malachite in the groundmass as altered silicates. In Fig.3:4, chalcopyrite occurs in association with magnetite in a base silicate as segregated type of ore deposits. It shows that copper and iron ore minerals crystallized simultaneously. In Fig.3:5, malachite replaces silicates. It shows that copper mineralization took place later than rock forming silicates. The ore minerals belong to late magmatic concentration. In Fig.3:6, granular magnetite are partially converted to martite. In Fig.3:7-3:10, goethite occurs in different forms along with magnetite and fine veins of malachite. The iron ores are much more than copper minerals. In the present context, copper minerals cannot be treated as ore. More works are necessary to locate copper deposits along this ophiolite belt.

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A PRELIMINARY STUDY OF BRYOPHYTES DIVERSITY IN THE VALLEY OF MANIPUR, NORTH-EAST INDIA

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Abstract

Bryophyte is the second largest of the land plants. Recently, all bryophytes group under three phyllum i.e Marchantiophyta (liverworts), Anthocerophyta (hornworts), and Bryophyta (mosses) are based on morphological and molecular data. The present study dealing with the diversity of bryophytes in the valley of Manipur, was carried out in May 2014 to January 2016. In this investigation a total of 25 taxa belonging to 24 genera and 17 families was identified. Eight (8) new species 4 (liverworts) i.e. Marchantia polymorpha L, Metzgeria furcata (L) Corda, Ricciocarpos natan (L) Corda, Plagiochasma appendiculatum Lehm.& Lindenb, 2 (hornworts) i.e. Anthoceros formosae Stephani, Notothylas indica Kashyap and 2 mosses i.e. Physcomitrium perflaccidum Broth. Ex P. de la Varde, Polytrichastrum formosum var densifolium (Wilson ex Mitt.) Z. Iwats. & Nog (mosses) are recorded in the state

Keywords: Bryophtes, Phyllum, Marchantiophyta, Anthocerophyta , Bryophyta, Manipur & Taxa.

Introduction

Bryophytes are the simplest and most primitive of land plant, representing the highest level of evolution and largest diversity among non vascular plants, next to Angiosperm. They favour wet and shady places but some species are found in arid region of the World. This group of plants has wide variety of morphological structures, representing prostrate and erect forms. The prostrate structure is regarded as liverworts whereas the erect structure is found in mosses. The plant body is made up of simple parenchymatous cells. But the outer wall or epidermis has waxy coating showing its terrestrial habitat. Simple root like rhizoids are found in both prostrate and erect forms. A mere tissue differentiation can be detected in mosses. Sexual reproductive structures

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are antheridium and archegonium with separate outer wall. The bryophytes are all gametophyte. They show sporophytic phase by the germination of sexually formed embryos. As unlike other cryptogams, the sporophyte is permanently dependant on gametophyte. Reproduction is done by spores produced by the sporophytes. The spore directly germinates to get gametophytic phase in the liverwort and via protonema in mosses. So, it is interesting to study the varied habitat with wide range of gametophytic and sporophytic stages in the life cycle of bryophytes (Watson, E.U.,1974).

According to recent classification, all the known bryophytes are grouped under three divisions (phyla)i.e Marchantiophyta (liverworts), Anthocerophyta (hornworts), and Bryophyta (mosses), based on morphological and molecular data. The bryophytes, the second largest group of green plants after angiosperms deserved a much important place than what they have today in biological research. They have remained as a neglected group of plants till the recent past in spite of their importance in establishing ecosystem stability, nutrient recycling, bio indicators of environment, providing microhabitat for other plants and animals and in other aspects.

The latest checklist of the bryophytes of India by Diya Dandotiya et al (2011) recorded 2489 taxa of bryophytes comprising 1786 species in 355 genera of mosses, 675 species in 121genera of liverworts and 25 species in 6 genera of hornworts. As regard the floristic study of Manipur is concerned, the contributions are mainly confined to vascular plants. The contributions on the bryophytes of Manipur can be seen from the work of D.C., Deb,(1955), D.B. Deb (1960), R.S. Chopra (1975), H.C. Gangulee (1980) and J. Lal (2005). Other relevant contributions of Bhattacharyya, P. K (2005), Ghosh, J. P (2006), Singh, S. K. et. al (2007), Shaya Sathisk, S (2003) & Ramchandra Laha (2015) are also discussed during the studies. The present study is based on investigations during a period of 21 months only in the valley area of the state. The absence of enough literature and guidelines creates a great challenge in the study of this interesting group of plants.

Study area

Manipur is a small hilly state located in the North-Eastern border of India between 23°80′N to 25°68′N latitude and 93°03′E to 94°78′E longitudes. The state is bounded on the North by Nagaland, on the South by Mizoram, on the East by Myanmar and West by Assam with an area of 22327 sq. km. and an elevation of 550- 3600 MSL. The average rainfall reaches up to 1000mm. The major portion of the state consist of hill ranges with a North and South general trend. Geologically, the state is of recent origin. A greater part of the state is occupied by a series of shales and sandstones. The tertiary sediment units

cover about 90 % of the area of Manipur. The central valley is made up mostly of clay soil with enough sediments. Many wetland areas are found scattered in the valley. The flat and elevated valley of an area of about 1545 sq. Km. constitutes the central valley of Manipur. It is extended 43.3 km in length from East to West (Andro to Keithelmanbi) and 32.2 km. in breath from North to South (Sekmai to Sugunu). It is an elevation of about 750 MSL and slightly sloping toward the South. The valley portion is only one tenth of the total area consisting four districts i.e. Imphal West, Imphal East, Bishnupur and Thoubal. (Annexure: 2)

Material and Method

Random sampling method was carried out in different localities of study site during May 2014 to January 2016. The collected plant specimens are preserved in the form of herbarium. A special type of herbarium sheet was designed for the purpose (14 cm x 12 cm) and kept closed by using polythene bags of appropriate sizes. For the morphological study of some species, the dried herbarium specimens were soaked in tap water for about 2 hours to stretch them to their original shape. External morphology and anatomy had been studied under microscope. Photograph of some of the plants had been taken at their respective collection sites. Good plant materials of a small number of species was collected. In some cases, the fruiting bodies were hard to collect. Repeated collection was also arranged in some interested areas. Collection work had been conducted in accordance with the instruction given by S. K. Jain & R.R. Rao (1977). The identification of the taxa had been done in the laboratory by studying the specimen and consulting various relevant literatures, flora, monograph, publication, experts and also used internet facilities. Based on the recent classification system, the families and genera used in this lists are followed by Crandal -Stotler *et al.*(2009),Renzaglia *et al.*(2008), and Goffinet *et al.* (2008) for liverworts, hornwort and mosses. All the collected specimens were deposited to the Department of Botany, Imphal College Imphal for further study and references.

Discussion & Conclusion

The present study area in the valley of Manipur revealed a total of 25 taxa of bryophytes distributed under 23 genera and 17 families. The details of the species identified is given below. Seven families were identified under the Phylum Marchantiophyta (liverworts): Aytoniaceae have two genera, Lejeuneaceae (1 genera), Marchantiaceae (1 genera), Metzeriaceae (1 genera), Ricciaceae (2 genera). Two families

It is necessary to encourage interested persons and experts in the field and to develop a reference herbarium. A national or state level website or database is urgently required.

Alphabetical list of bryophytes during the ongoing survey. (The new species records are indicated with a '#'mark)

Phylum : Marchantiophyta (Liverworts)

Family : Ayotoniacae

1. *Asterella khasiana* (Griff.) Grolle, Khumbu Himal 1(4): 267 1966.

2. *Plagiochasma appendiculatum* Lehm.& Lindenb., Nov.Strip. Pug. 4:14 1832.

Family: Lejeuneaceae

3. *Lopholejeunea sikkimensis* Stephani, Sp. Hepat. 5: 87 1912.

Family: Marchantiaceae

4. *Marchantia polymorpha* L., Sp. Pl. 1137 1753.

Family: Metzgeriaceae

5. *Metzgeria furcata* (L) Corda, Naturalientausch 12: 654 1829.

Family : Ricciaceae

6. *Riccia frostii* Austin, Bull.Torrey Bot. Club 6: 17 1875.

7. *Ricciocarpos natan* (L) Corda, Naturalientausch 12: 651 1829.

Phylum: Anthocerotophyta (hornworts)

Family: Anthocerotaceae

8. *Anthoceros bharadwajii* Udar & A.k Asthana, Indian Natl. Sci. Acad., B 51:484.Pl. 2:f.1-2 1985.

9. *Anthoceros formosae* Stephani Sp. Hepat. 5: 1002 1916.

Family: Notothylaceae

10. *Notothylas indica* Kashyap, Lahore phil. Soc. 4: 49 1925.

Phylum: Bryopyta (mosses)

Family : Brachytheciaceae

11. *Brachythecium buchanannii* (Hook.) A. Jaeger, Ber Thatigk. St.Gallischen Naturwiss. Ges. 1876-77: 341 (Gen. Sp. Musc. 2: 1159) 1878.

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Family: Bryaceae

12. *Bryum argenteum Hedw.*, Sp. Musc. Frond. 181 1801.
13. *Gemmabryum apiculatum* (Schwagr,) J.R. Spence & H.P. Ramsay, Phylogia 87: 65 2005.

Family: Fissidentaceae

14. *Fissidens nobilis* Griff., Calcutta J. Nat. Hist. 2: 505 1842.

Family: Funariaceae

15. *Funaria hygrometrica* Hedw., Sp. Musc. Frond. 172 1801.
16. *Physcomitrium perflaccidum* Broth. Ex P. de la Varde, Rev. Gen. Bot. 29: 299 1917.

Family: Hylocomiaceae

17. *Macrothamnium macrocarpum* (Reinw. & Hornsch.) M. Fleisch., Hedwigia 44: 308 1905.

Family: Octoblepharaceae

18. *Octoblepharum albidium* Hedw., Sp. Musc. Frond. 50 1801.

Family: Polytrichaceae

19. *Polytrichastrum formosum var densifolium* (Wilson ex Mitt.) Z. Iwats. & Nog., J. Hattori Bot. Lab. 37: 389 1973.
20. *Pogonatum contortum* (Menzies ex Brid,) Lesq., Mem.Calif,acad. Sci. 1: 27 1868.

Family: Pottiaceae

21. *Didymodon asperifolius* (Mitt,) H.A. Crum,Steere & L.E. Anderson, Bryologist 67: 163 1964.
22. *Hyophila involuta* (Hook.) A. Jaeger, Ber Thatigk. St.Gallischen Naturwiss. Ges. 1871-72: 354 (Gen. Sp. Musc. 1: 202) 1873.
23. *Semibarbula orientalis* (F. Weber) Wijk & Margad., Taxon 8: 75 1959.

Family: Sphagnaceae

24. *Sphagnum khasianum* Mitt., J. Proc. Linn. Soc., Bot. Suppl. 2: 156 1859

Family: Stereophyllaceae

25. *Stereophyllum setschwanicum* Broth., Akad. Wiss. Wien Sitzungsber., Math.-Naturwiss. Kl., Abt. 1, 133: 581 1924.

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JIRIBAM - TIPAIMUK UPPER BARAK BASIN IN MANIPUR: A STUDY ON LANDSCAPE DEVELOPENT

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Abstract

Jiribam, in Upper Barak Basin in Manipur is a contiguous part of the Barak Valley of Assam, represented by a synclinal small valley, surrounded by sub-meridional anticlinal hills and mountains with a thin skinned tectonic resulted in deformation of Neogene clastics, which is manifested in the form of a series of anticlines and synclines. These structural elements had controlled the development of present day landscape in this sub-basin producing a series of ridges and strike valleys of alluvial plains, which were further subjected to erosion and deposition activities leading to development of topographic high and low surface in different parts. This paper examines the geomorphological settings of the basin to identify the processes of landscape development in the area coordinated with other geographical aspects.

Key Words : Argillaceous Sediment, Piedmont zone, Synclinal structure, Denudo structural.

Introduction

The Jiribam Barak Basin is an upper part of the second largest river basin in the north east India, *the Barak Basin or the Barak Valley of Assam*, a part of the Surma-Meghana River System, as a constituent part of the Ganga-Brahmaputra River System in Bangladesh. It has unique topographic features with the Manipur central valley, along the western flank lying beyond the pale of the Manipur Western Hills. This basin has a complex topography and climatic conditions. The subject of tectonic geomorphology deals with the impact of tectonic base level, which falls on the processes and morphologies of the fluvial system; and assessment of the relative degrees of tectonic activity of mountain fronts or other structural elements, during the Quaternary period. The analysis

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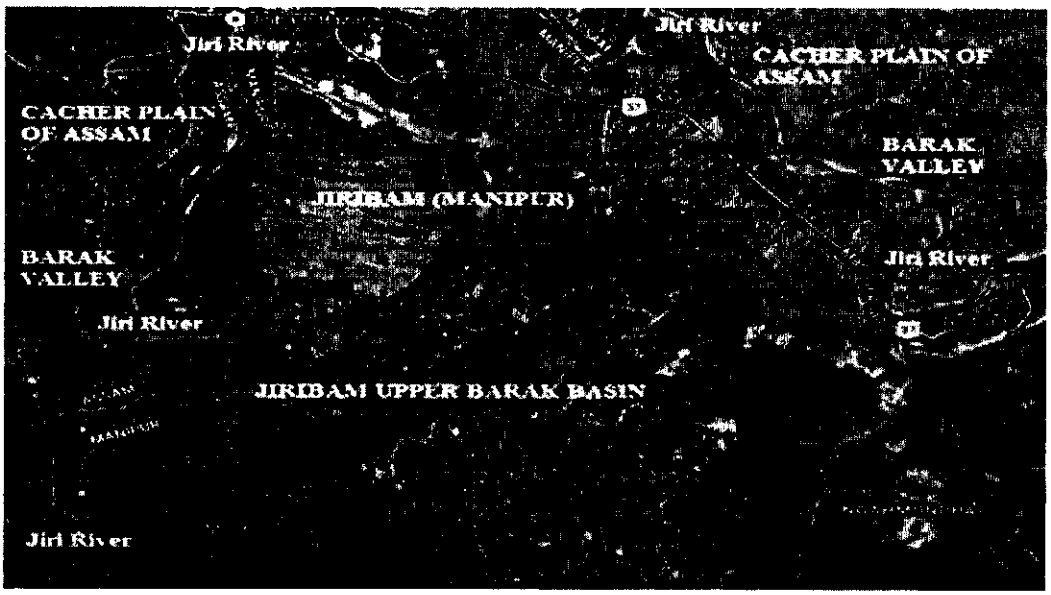
of active structures can be done by using morphometric indices, which are sensitive to rock resistance, climate changes and tectonic processes resulting into landscape evolution. Remote sensing plays a significant role in providing spatial information needed for computation of these results. Structural control of landscape evolution for the fold mountain belts had been done by many scholars in different fields, however, information on the landform evolution of this area, particularly in their relation to the existing geomorphological set up of structural and tectonic development is found to be very scanty. This paper presents a short geographical account of the study area, the landscape settings and structural control on their evolution. Limited morphometric analysis is done to substantiate the role of active tectonics in the development of the area.

Study Area

Jiribam is a small sub-basin of the Barak Basin of the Surma-Meghana River system located within the territorial limit of the state. The Barak River is one of the major rivers of South Assam originating from the southern spur of the Mt. Javo (3015 mts) of Nagaland and northern slopes of the Liyai Hills of Manipur, about 16 km towards the east from Mao in Senapati district of Manipur. The Jiribam Upper Barak Basin is a part of the Surma (BaraK)-Meghana River System; this basin includes a part of Jiribam



Jiribam Upper Barak Basin

district (newly formed) and part of Parbung (newly formed) Tipaimuk Sub-division of Pherjol district, which extends in the western flank beyond Manipur western hills. The study area (sub-basin) covers an area of 250 km^2 (171 km^2 of Jiribam and 79 km^2 of Tipaimuk) out of the total Barak drainage area of the state (9,550 km^2) within $24^0 0'$ to $24^0 48'$N Latitudes and $93^0 0'$E to $93^0 12'$E longitudes, bordering Tamenglong hills in the north and a part of east; Pherjol hills in the south and a part of east; and in the west by the open Cachar plain or Surma valley of Assam.

Data Base and Methodology

The methodology employed in the study includes the morphometric techniques to access geometry and forms of the basin with special reference to the characteristics of slopes, which explains the causative interrelationship between qualitative and quantitative variables of geomorphology and hydrological parameters of climatic variables. Available methods of basin analysis and literatures have been used based on primary and secondary data, and related information supported by intensive field verifications. This study will follow up on these non-linear parameters computing the laws of R.L. Singh (1974, Sen (1993), Maitra (1996) and Betal (2010). The entire work have been carried out using geomorphological and hydrological analysis with identification of other geographical aspects of the sub-basin by using remote sensing and GIS techniques.

Objectives

The main objective of this study is to assess the geomorphological characteristics of the Jiribam sub-Barak basin area by using satellite GIS and Remote sensing data and identified geological and hydrological parameters of the basin with the identification of other geomorphological aspects.

Geomorphological Settings

Geology

Jiribam Barak basin is a sub-basin of the Cachar-Tripura-Arakan tectonic sedimentary basin known as Barak Basin, in a foredeep accretionary basin between the Indian craton and Indo-Myanmar plate collision zone (Alam, 2013). The diluvia fringe of the basin was filled with loose talus. The depositional event of the area is observed to be repeatative succession of Neogene arenaceous and argillaceous sediments of rhythmites with thinning upward sequence (Nandy, 2001). The marine origin rhythmites were followed by fluvial deposits later. The sedimentary column of this basin is made up of

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sandstone, siltstone, shale, mudstone, conglomerate and unconsolidated sediments ranging from clay to boulders, which are exposed at various depths due to folded nature of the rocks. The oldest underlying rocks of the area belongs to the Disang group (Eocene) followed by the Barails (Oligocene), the Surma (Miocene) and the Tipam (Mio-Pliocene) with the Dupi-Tila (Plio-Pleistocene) and the Dihing group (Pleistocene) followed by alluvium of Pleistocene to Recent age.

Structure

Structurally, the area of the basin is characterized by meridonal to sub-meridonal, arcuate, elongate and asymmetrical folds trending north to south with slight convexity towards the west (Ganguli, 1984). The regional structural deposition and tectonic activity in the region have significant effect on the landscape development during the Quaternary period; and most of the landforms are a result of tectonic activity or are carved out from the pre-existing landforms by erosional processes. It is observed from the works on regional geology and tectonics done by Evans (1964), Ganguly (1975), Dutta (1976), Nandy (1982) and Seshavataram (1998) that the tightness of folding increases towards east as it approaches the Arakan-Yumas collision zone

Jiribam ; Topography

Topography

Two major topographic divisions can be observed in the sub-basin, as the valley and the hills and mountains. The plains are thickly populated and extensively cultivated; while the hills and mountains are skinned by thick forests. The topography of the basin is a striking feature as it is a sub-basin of the Surma valley of Assam with a gradient towards the west from the east, north-east and south east; well drained by the Barak River system with its tributary the Jiri River. The eastern part of the basin is piedmont zone of alluvial fans along the foothills with an elevation of 500 meters; the western part of it is below 100 meters from the mean sea level respectively. The central part of the basin is an alluvial plain scattered with low sandstone hillocks standing above the alluvium; these are eroded residual synclinal structures. The maximum elevation in the central part of the basin is found to be 246 meters near the Sorma-Punji and minimum of 95 meters from the mean sea level near Jakurdhor-II village. The upper part of the basin in the eastern, southern and northern side is represented by denudo-structural hills of 500 to below 1500 meters; the outer part of the basin particularly in the north, east and south the surface is above 2000 meters; however, the western part is an open valley of the Cachar plain of Assam.

Slopes

The slope of the basin, in the central alluvial plain is nearly level of 1^0 – 2^0 slope from east to west; the eastern part of it is very gentle along the foothills of the piedmont alluvial fans at 2^0 to 3^0 slope; above the piedmont zone the slope is gentle of 3^0 to 5^0 and partly moderate slope of 5^0 to 10^0. The upper part of the basin in the east and south, the slope is strong of 5^0 to 10^0; while in the north the slope is strong to steep of 10^0 to 25^0; the outer part of the basin the slope is scarp steep of above 60^0. The shape of the basin is an open valley towards the west, where the slope is nearly level similar to the central part.

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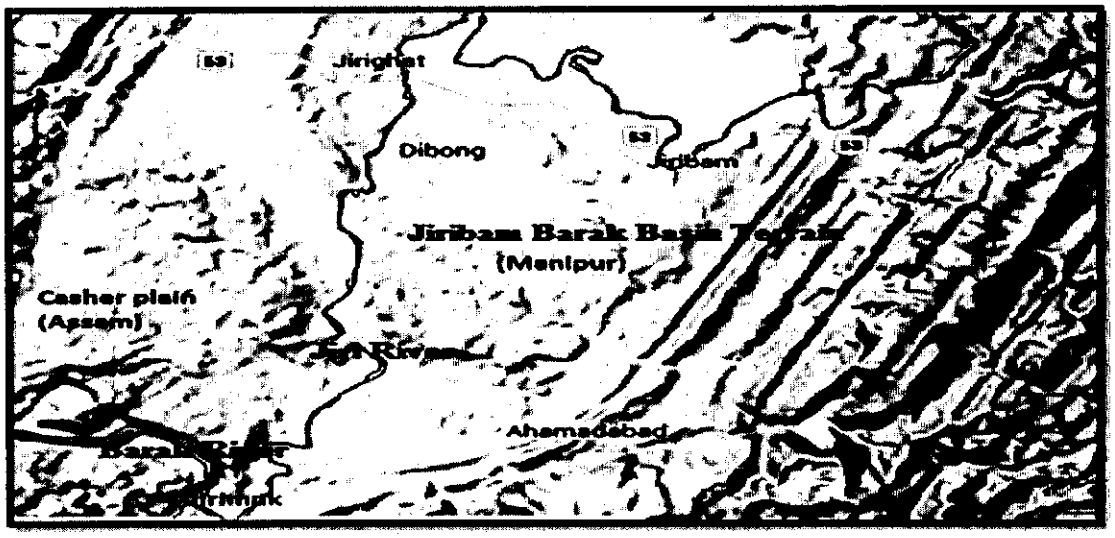

Jiribam; Slope

Soils

The soil of the basin is a slight variation from Udalfs-Ochrepts to Ochrepts-Aquepts-Fluvents based on structure, formed by Tipam series and Chengapara formation (Garo Hills). The predominant soil type of the sub-basin is lateritic red and yellow alluvium.

Climate

The sub-basin area has three seasons viz. (i) dry season, (ii) rainy season, and (iii) cold season, characterized by short winter, long summer with heavy rainfall, and moderate climatic condition of neither too hot nor too cold throughout the year. The annual rainfall is very significant ranging to 100-180 cm; of which, about 20-30 percent is received during the pre-monsoon period of May; about 60-70 percent is received during the rainy season of June to September ranging from 100-160 cm. It continues till November; and a meager quantity of frosts are found during December.

The temperature of the area is humid with moderately hot. May and June is driest and hottest months. May is the hottest with an average monthly temperature of 36.8^{0}C. Autumn season is very pleasant in September-November. December and January is the coldest months of below 2.78^{0}C. However, days are comfortably warmer and nighs are colder.

Natural Vegetation

The natural vegetation of the Sub-basin is mostly tropical evergreen and there are large tracts of rainforest in the north and south-eastern part of the catchment area. The floras in the catchment areas of the sub-basin were once rich in wild life, but now vanishing due to human onslaught. Among the rare species of fauna are Hoolook Gibbon, Phayre's leaf Monkey, Pig tailed macaque, stump tailed macaque, masked fin-foot, White winged wood duck etc.

Drainage Analysis

The Barak is one of the largest rivers of south Assam and, is a part of the Surma-Meghana River system, rises from the hill country of Manipur, where it is the biggest and most important river (Wikipedia, 2015). The western half of the state is drained by the Barak River through Dhansiri River into the Brahmaputra - Ganga River system. The study area falls in the upper part of the Barak River basin in Manipur State. The Barak River drains about 250 km^2 of its river valley in the western half of the state. The important tributaries of the river Barak in the study area are the River Jiri and Tuivai. The Barak River in Manipur originated from the Barail Range of North east India, at the southern spur of the Mt Javo (3015 m) in Nagaland and northern spur of the Liyai

Jiri-Barak Drainage

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hills of Manipur, called "***Sangulok***"; the meaning is "***River of many streams or River of rivers***"; it also called, *Mbeiki* by Zemis, *Agu* by Liangmei, *Range* by Rongmei, *Gwai* by Meeteis and *Barak* by Dimasas in the Cachar plain of Assam; it flows towards the south west through the mountainous terrains of the Manipur western Hills up to Tipaimuk, near the tri-junction of Assam-Manipur-Mizoram states. The sudden widening followed by compressed valley are observed along the course of the river Barak and river Jiri near Jiribam; it may be due to the sudden appearance of hard and compact lithology or some structural complexities in the area showing anomalous drainage pattern. After getting water of the Tuivai River at Tipaimuk, it took a hairpin bend of upstream towards the north up to Jirimuk or Jirimat. At Jirimuk it joins with the Jiri River and leaves Manipur near Lalpur, debouches into the Cachar plain of Assam and Sylhet plain of Bangladesh to form the river Dhanshiri; it divides into two streams in its mouth, the River Surma and the River Kushiyara to join into the Ganga-Brahmaputra River system in Bangladesh to form the River Meghana and the River Padama (Nabakumar, 2015).

The total length of the Barak River from its source to the Indo-Bangala border is 564 km (Wikipadia, 2015); of which, 475 km is in the Cachar plain of Assam and about 89 km is in the Manipur Western Hills. The course of the river Barak flows through narrow steep sided valleys which strikes almost north-east to south-west direction. The adjoining hill ranges also strikes parallel to their valleys. The river and its streams are mostly represented by dendritic to sub-dendritic drainage patterns. The course of the main river is rather straight in the northern part, but it is progressively more sinuous at the southern part. Tuivai and Jiri Rivers in the sub-basin area are the main tributaries of the Barak and each of them has similar dendritic drainage pattern

Hydrological Parameters

The Barak drainage area in Manipur covers about 9,550 km^2; of which Jiribam sub-basin area is about 171 km^2 and Tipaimuk sub-basin area is 79 km^2 with a total 250 km^2 of Jiribam-Tipaimuk sub-basins area. The main source of water of the river Barak and its constituent tributaries are rain with an annual rainfall of 100-180 cm and seepages of the rocks. The basin has no glaciated topography. The hydrological parameters of this sub-basin area can be observed from the following table.

Hydrological Parameter of Jiribam-Tipaimuk Upper Barak Basin

1	2	3
Name of the Basin/Sub-Basin	Catchment area in Km^2	Annual average yield of Water in mham
1. Barak River including Irang, Makru rivers and other tributaries;	6,866	0.8412
2. Tuvai River	1,860	0.3453
3. Jiri River	316	0.1430
Total Basin	9,042	1.3295

Source; IFCD, Imphal, Manipur.

The Barak River with a catchment area of 6,866 km^2 in the Manipur western hills contributes an annual average yield 0.8412 million hectare meter (mham) of water. The Tuivai River originating from the Hills Mizo of Mizoram with a catchment area of 1,860 km^2 in the Manipur southern hills of Pherjol district shares 0.3453 million hectare meters (mham) of water per annum; and the Jiri River with 316 km^2 of catchment area added an annual average yield of 0.1430 million hectare meters (mham) of water. Thus, the Barak River system in its upper course at Jiribam-Tipaimuk sub-basin provides an annual average river water of 1.3295 million hectare meters (mham) in the north eastern region of India. The Barak River has hydro-power potential of 3908 MW at 60 percent load factor. This small sub-basin can contribute less than 20 percent of the total surface water potential (48.4 km^3) and ground water potential (1.8 km^3) of the total Barak Basin area (Manipur and Assam) of 41,157 km^2 (Wikipedia, 2015).

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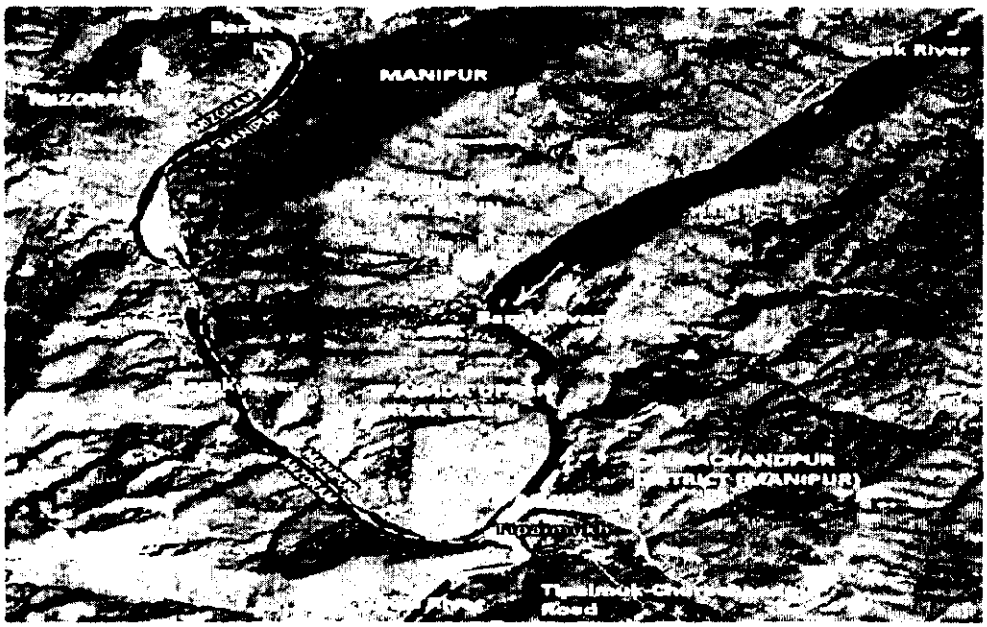

Tipaimuk Upper Barak Basin; Drainage

Conclusion

The Jiribam Barak Basin is a small sub-basin of the upper Barak Basin of the Surma-Meghana River System and one of the biggest river systems in Manipur west. This sub-basin area is a part of the Surma valley of Assam. Geologically, the oldest underlying rock of the area belongs to the Disang group followed by the Barails, the Surma, the Tipam with alluvium cover of Recent. Structurally the basin is characterized by elongated asymmetrical folds tending north to south with slight convexity towards the west. The topography of the basin is an alluvial plain scattered with low hillocks, gently sloping towards the south with a shape of open valley towards the west, characterized by sub-tropical monsoon climatic condition of humid with moderately hot; the soil of the basin is typically of lateritic red and yellow aluvium. The drainage of this sub-basin is represented by dendritic to sub-dendritic drainage pattern. The entire landscape of this sub-basin is a very complex one, developed during the Quaternary period resulted from tectonic activity.

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POPULATION DISTRIBUTION IN MANIPUR : A STUDY ON GEO-SPATIAL ANALYSIS

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Abstract

The concepts of distribution and density of population though not identical, yet are so intimately related with each other. Distribution and density of population are the two fundamental problems in population studies of an area related to all other features of population. Manipur has two geographical units of a valley and hills and mountains. The valley occupied about 10.02 percent and the hills and mountain covered 89.98 percent of the total state geographical area. This leads to different spatial concentration of population in state. This paper analyzed geo-spatial distribution of population correlated rank size rule, concentration index, location quotient and population potential of the state.

Key words : Concentration index, Location quotient, Potential, Linear, Dispersed, Nucleated, Agglomerated, Choropleth, Isopleths, Median point, Rank- size rule.

Introduction

Distribution of population refers to the way people are spaced over the surface of the earth (Nabakumar, 2014). It emphasizes the pattern of actual place – location of a population (Ghosh, 1985). It also refers to the spatial pattern, in which, the population find its location such as linear dispersed, nucleated agglomerated, etc. and the density is concerned with the ratio between the size of population and the area. Thus, when it is dealing with distribution, the concern is the pattern of the spread of population and when it is dealing with density, the concern is man and land ratio. (Chandna, 2011).

The term distribution refers to the placing of men during that part of human life- span only which is spent in an inactive subconscious state. This state is achieved

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in sleep which takes place under the roof of human dwellings. This sleeping life is generally spent in groups called family or household. While in action, a man is seldom static and fastened to a particular point in space. Geographical distribution of population is, therefore, the distribution of family or households which would ultimately mean the distribution of human dwellings and settlements. This leads that the distribution of population should actually mean the distribution of villages. Thus, the distribution of population implies exact placing of population on a particular unit of area.

There are several methods to analyze the distribution of population, in rural and urban. **Stilgenbauer's** method and **Sten de Geer's** method have tried to solve the problems of both rural and urban. Therefore, apart from dot method, choropleth method and isopleths method, several other methods of describing the spatial distribution of population have been developed. Among different methods, percentage distribution, rank size rule, median point, mean point, population potential, concentration index and location quotient are the main methods to show population distribution of this study.

The study area:

The study area covers the total geographical area of Manipur, extending between $23^0 51'$N and $25^0 41'$N latitudes and $93^0 21'$E and $94^0 47'$E longitude; bounded by Nagaland in the north, Mizoram in the south, upper Myanmar in the east and Cachar district of Assam in the west. The state has a total geographical area of 22, 327 sq.km, constituting only 0.68 percent of the total area of the country, India. It comprises 16 districts, 38 sub- divisions with a population of about 28.56 lakhs in 2011.

Objective

The main objective of this paper is to analyze the geo-spatial distribution pattern of population in the state using the methods of location quotient, concentration index, and rank-size rule and population potential, concerns with identifying the areas of less or more concentration of population in different parts of the state.

Methodology

To analyze the spatial distribution of population of the state, data have been obtained from Census of India, and methods of location quotient (L.Q), concentration index (C.I), rank size rule and population potential have been utilized for better explanations.

1. Location quotient (LQ)

$$LQ = \frac{\frac{Total\ Rural\ or\ Urban\ population\ of\ the\ area}{Total\ population\ of\ the\ area} x\ 100}{\frac{Total\ Rural\ or\ Urban\ population\ of\ the\ state}{Total\ population\ of\ the\ state} x\ 100}$$

Location quotient which gives us the relative picture of such proportions is defined as the ratio of the proportion of a particular characteristic in an area to the same proportion in the region (Aslam, 1998). Location quotient measures the degree to which a specific region has more or less than its share. A location quotient of 1.0 mean, an area of having neither more nor less of the area's population than its overall volume of population. A quotient over 1.0 indicates a high concentration in that area relative to the whole of the State. A quotient less than 1.0 suggests that the population distributed is less in number in that area than in general (Alexander, 1977). Location quotient reveals the share of population in relation to its total population and expressed in the form of low, high and identical.

2. **Concentration Index**

$$CI = \frac{Actural\ population\ of\ the\ unit\ are\ (sub-division)}{Average\ population\ of\ a\ unit\ area\ (sub-division)}$$

The index of concentration is a measure of the degree to which an activity or distribution is concentrated regionally (Chandna, 2011). This index reveals the share in relation to its average.

3. **Population potential = P/r**

Where, **P** = population and **r** is the distance from each area to the point concerned.

This model is referred by **Stewart** as a measure of nearness of people to a point. It assumes that the influence of population is inversely proportional to the distance. With the help of this potential value "isopleths also be used with the effect in plotting potentials of population". Thus, using this technique, contour of population potential can be computed and drawn for the state of Manipur.

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4. Rank size rule = $Pr = K_R^{-b}$

Where Pr is the population of the unit/ area whose rank is R. while K and b are the constant. Where, K can be interpreted as the expected population of the largest unit and b as the slope of the linear relationship.

Rank size rule is the analysis of the total settlement network in a region. Hence, it is tool which aims of analyzing settlement system and helps in describing and interpreting the relationship between the rank and population size of the settlement places in the sub- divisions. Thus, plotted on a double log paper the population of the specific area and ranks, a scatter diagram can be formulated verifying the distribution pattern. Low population sub- divisions have low ranks and have more numbers of having sparsely population distribution than the places of higher concentration of population with high ranks (Table- 1)

Table – 1: Rank and Population Potentiality of Sub- divisions of Manipur, 2011.

Sub- division	Rank	Population potentiality
Porompat	1	73,966
Lamphelpat	2	67,098
Lamshang	12	15,153
Sawombung	11	12,860
Keirao-Bitra	13	9,216
Wangoi	6	9,042
Thoubal	3	9,059
Patsoi	15	8,030
Lilong	10	6,241
Kakching	7	4,234
Nambol	19	3,868
Churachandpur	4	3,109
Moirang	8	2,967
Bishnupur	18	2,414
Saitu- Gamphazol	20	2,395
Mao- Maram	5	2,334
Sadar Hills East	17	2,281
Sadar Hills West	14	2,086
Ukhrul Central	9	2,065

Tamenglong	23	1,141
Purul	16	1,058
Chakpikarong	22	802
Paomata	21	735
Nungba	26	733
Tamenglong North	31	682
Purul	16	1,058
Chakpikarong	22	802
Paomata	21	735
Nungba	26	733
Tamenglong North	31	682
Chandel	27	642
Churachandpur North	29	612
Jiribam	24	563
Tengnoupal	25	561
Machi	34	484
Tamenglong West	32	454
Ukhrul North	28	408
Phungyar- Phaisat	37	376
Ukhrul- South	38	348
Kamjong- Chassat	36	294
Singhat	33	291
Tipaimukh	30	290
Thanlon	35	220

Source : *Census of India, Primary Census Abstract, Manipur Series- 15, 2011 and potentiality index has been computed by author.*

Population Distribution

The population of Manipur was 28,55794 persons in 2011; of which 2,021,640 lived in rural areas and 8,34,154 in the urban areas; and about 89.98 percent of the state total area is covered by hill and mountains being agriculturally less productive and less support of life resulting sparse distribution of population. About 60 percent of the state population lived in the valley and 40 percent lived in the hilly region. Higher concentration of population is seen in the Porompat (5.55 %), Lamphelpat (7.75 %), Thoubal (6.98 %), Churachandpur (6.10 %) and Mao-Maram (5.72 %) sub- divisions with percentage of population is higher than 5.0. The least population distribution is found in Ukhrul South sub- division with 0.43 percent (Fig. 1)

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Rural Population

To find out the distribution pattern and to measure the degree to which a sub-division has more or less population than its share location quotient is used. Among 38 sub- divisions of the state, the index of location quotient shows a higher concentration of rural population in 25 sub- divisions.

They are Mao- Maram, Paomata, Purul, Saitu Gamphazol and Sadar Hills East in Senapati district; four sub- divisions each in Tamenglong, Churachandpur and Ukhrul districts; and three sub- divisions Chandel, Machi, and Chakpikarong in Chandel district. All sub divisions of Senapati and Churachandpur districts, Tamenglong North, Tamenglong West, Nungba, Lamshang, Jiribam, Sawombung, Keirao, Bitra, Ukhrul North, Kamjong- Chassad, Phungyar- phaisat, Ukhrul South, Machi, Chandel and Chakpikarong sub- divisions, the location quotient index is higher than 1.0 respectively. In Tamenglong, Nambol, Bishnupur, Moirang, Lilong, Thoubal, Kakching, Patsoi, Tengnoupal and Ukhrul central sub- divisions, the rural population is more or less identical as location quotient is 1.0 respectively. But, Wangoi, Porompat and Lamphelpat sub- divisions, the rural population is much dispersed as location quotient is less than 1.0 (Table2)

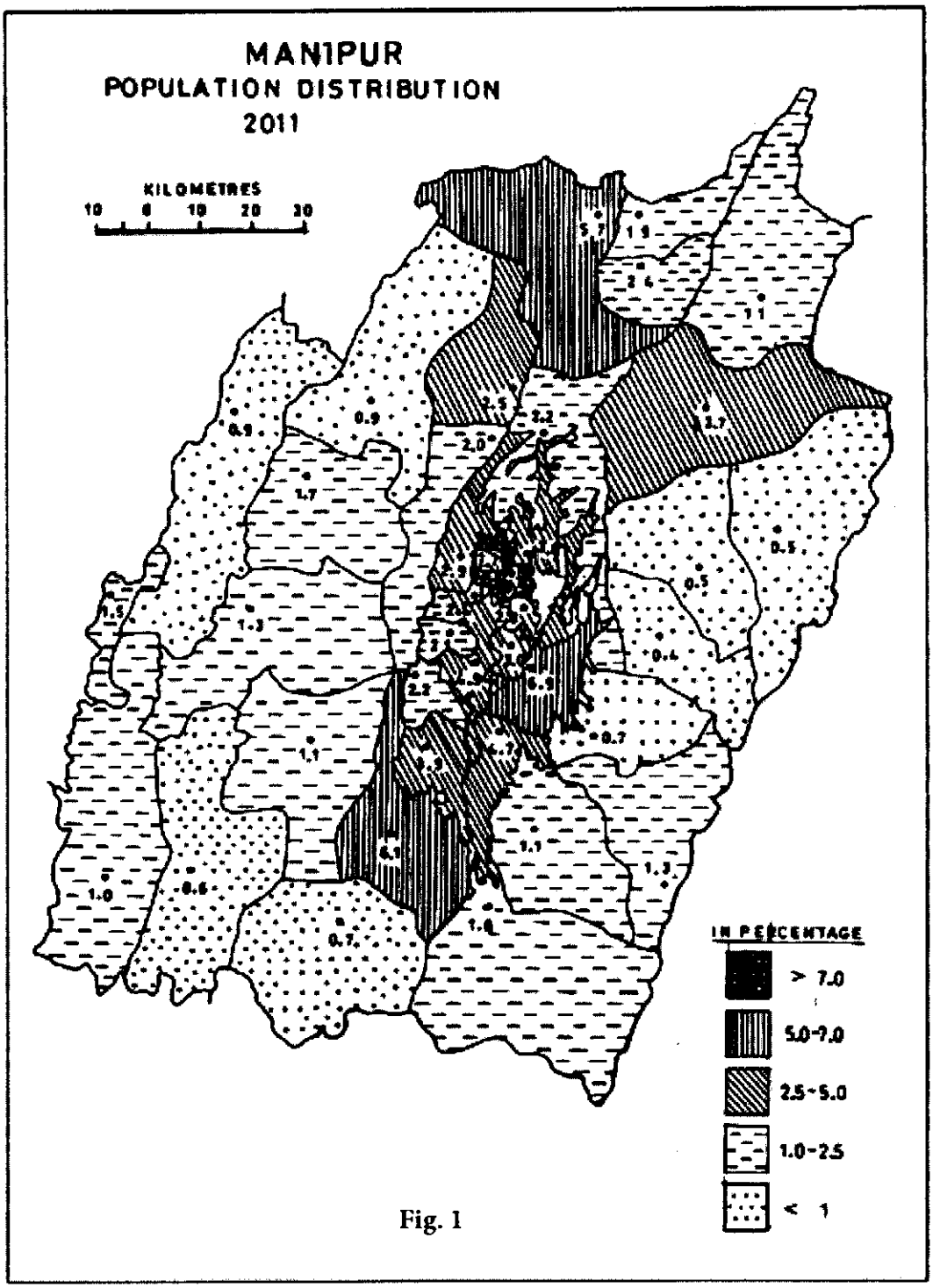
MANIPUR
POPULATION DISTRIBUTION
2011
KILOMETRES
10 0 10 20 30
IN PERCENTAGE
> 7.0
5.0-7.0
2.5-5.0
1.0-2.5
< 1

Fig. 1

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Table- 2 : Sub-division wise distribution of Location Quotient for Rural and Urban population of Manipur, 2011.

Sub Division	Population			Percentage of population to the total population			L.Q. for population	
	Total	Rural	Urban	Total	Rural	Urban	Rural	Urban
Mao-Maram	163,380	163,380	-	5.72	100.00	-	1.41	-
Paomata	53,901	53,901	-	1.89	100.00	-	1.41	-
Purul	68,123	68,123	-	2.38	100.00	-	1.41	-
Sadar Hills West	71,844	64,368	7,476	2.52	89.59	10.40	1.26	0.36
Sadar Hills East	63,364	63,364	-	2.22	100.00	-	1.41	-
Saitu-Gamphazol	58,536	58,536	-	2.05	100.00	-	1.41	-
Tamenglong North	28,056	28,056	-	0.98	100.00	-	1.41	-
Tamenglong West	27,742	27,742	-	0.97	100.00	-	1.41	-
Tamenglong	48,182	28,819	19,363	1.69	59.81	40.19	0.84	1.37
Nungba	36,671	36,671	-	1.28	100.00	-	1.41	-
Tipaimukh	28,795	28,795	-	1.01	100.00	-	1.41	-
Thanlon	18,464	18,464	-	0.65	100.00	-	1.41	-
CCpur North	30,616	30,616	-	1.07	100.00	-	1.41	-
Churachandpur	1,74,138	1,55,781	18,357	6.10	89.46	10.54	1.26	0.36
Singhat	22,130	22,130	-	0.77	100.00	-	1.41	-
Nambol	61,882	37,640	24,242	2.17	60.83	39.17	0.86	2.20
Bishnupur	62,778	37,533	25,245	2.20	59.79	40.21	0.84	1.38
Moirang	1,12,739	74,721	38,018	3.95	66.28	33.72	0.94	1.74
Lilong	87,377	58,628	28,749	3.06	67.10	32.90	0.95	1.68
Thoubal	1,99,310	1,25,375	73,935	6.98	62.90	37.10	0.89	1.27
Kakching	1,35,481	86,832	48,649	4.74	64.09	35.91	0.90	1.22
Lamshang	84,856	71,661	13,195	2.97	84.45	15.55	1.19	0.53
Patsoi	70,665	49,190	21,475	2.47	69.61	30.39	0.98	1.04
Lamphelpat	2,21,422	9,723	2,11,699	7.75	4.39	95.61	0.06	3.27
Wangoi	1,41,049	64,539	76,510	4.94	45.76	54.24	0.65	1.86
Jiribam	43,838	36,495	7,343	1.54	83.25	16.75	1.17	0.57
Sawombung	86,162	81,561	4,601	3.02	94.66	5.34	1.34	0.18
Porompat	2,44,089	83,582	1,60,507	8.55	34.24	65.76	0.48	2.25
Keirao Bitra	82,024	71,268	10,756	2.87	86.89	13.11	1.23	0.45
Ukhrul North	31,004	31,004	-	1.08	100.00	-	1.41	-
Ukhrul Central	1,07,378	80,191	27,187	3.76	74.68	25.32	1.05	0.87
Kamjong- chassad	16,717	16,717	-	0.59	100.00	-	1.41	-
Phungyar Phaisat	16,539	16,539	-	0,58	100.00	-	1.41	-
Ukhrul South	12,360	12,360	-	0.43	100.00	-	1.41	-
Machi	19,865	19,865	-	0.70	100.00	-	1.41	-
Tengnoupal	39,245	32,398	16,847	1.37	57.07	42.93	0.81	1.47
Chandel	32,133	32,133	-	1.35	100.00	-	1.41	-
Chakpikarong	52,939	52,939	-	1.85	100.00	-	1.41	-
MANIPUR	2,855,794	2.021,640	834,154	100.00	70.79	29.21		

Sources : *Data from Census of India, Primary Census Abstract, Manipur Series- 15, 2011 and Location Quotient index has been computed by author*

The index of concentration of rural population is highest in Mao-Maram sub-division followed by Churachandpur and Thoubal sub-divisions repectively. Eighteen sub- divisions of Paomata, Purul, Saitu- Gamphazol. Sadar Hills East, Lamshang, Moirang, Keirao- Bitra, Porompat, Wangoi, Ukhrul Central etc. have been moderate concentration of rural population; 17 sub- divisions of Tamenglong North, Thanlon, Phungyar Phaisat, Ukhrul South, Machi, Jiribam etc. have been lower concentration index of rural population. Lamphelpat sub- division has the least and kakching and Sawombung sub-divisions have remained stagnant with 2001. Hence, the meaning of the rural population location quotient and concentration index may be clarified. The case of Patsoi reflects as an example of ideal, which resulting of location quotient is near to 1.0. On the other hand concentration index of Mao-Maram sub-division has higher index of 3.07. This means Mao-Maram sub-division has maximum rural population than the average rural population of a sub- division in the state.

Urban Population

The values of location quotient show a higher concentration of urban population in Lamphelpat sub-division (3.27), Porompat (2.25). Nambol (2.20), Wangoi (1.86), Moirang (1.74), Lilong (1.68), Tengnoupal (1.47), Bishnupur (1.38) and Thoubal (1.3) sub- divisions respectively, as location quotient is more than 1.0. The ideal concentration of urban population is found in Kakching and Patsoi sub-divisions, as the location quotient is near 1.0.

In Sadar Hills West, Churachandpur, Lamshang, Jiribam, Sawombung and Keirao Bitra sub- divisions, the urban population is much dispersed as location quotient is less than 1. 0 (Table- 3)

In Manipur, the sub- division of Lamphelpat (9.64) has the highest degree of concentration of urban population followed by Porompat (7.31), Churachandpur, Wangoi, Thoubal and Kakching sub- divisions' respectively. On the other hand the sub- divisions of Moirang, Lilong, Nambol, Ukhrul Central, Bishnupur and Patsoi have moderate concentration of urban population; whereas Tamenglong, Tengnoupal, Lamshang, Sadar Hills West, Jiribam, Keirao-Bitra and Sawombung sub-division have been lower concentration index of urban population (Table-3)

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Table – 3 : Sub- Division wise concentration index for Rural and Urban Population (2011) in Manipur State.

Sub-division	Total Population	Total Rural population	Total Urban Population	Concentration index for population		
				Total	Rural	Urban
1. Mao-Maram	1,63,380	163,380	-	2.17	3.07	-
2. Paomata	53.901	53,901	-	0.72	1.01	-
3. Purul	68,123	68,123	-	0.91	1.28	-
4. Sadar Hills West	71,844	64,368	7,476	0.95	1.21	0.34
5. Saitu-Gamphazol	58,536	58,536	-	0.78	1.10	-
6. Sadar Hills East	63,364	63,364	-	0.84	1.19	-
7. Tamenglong North	28,056	28,056	-	0.37	0.53	-
8. Tamenglong West	27,742	27,742	-	0.37	0.52	-
9. Tamengong	48,182	28,819	19,363	0.64	0.54	0.88
10. Nungba	36,671	36,671	-	0.49	0.69	-
11. Tipaimukh	28,795	28,795	-	0.38	0.54	-
12. Thanlon	18,464	18,464	-	0.24	0.35	-
13. CCpur North	30,616	30,616	-	0.41	0.575	-
14. Churachandpur	1,74,138	1,55,781	18,357	2.32	2.93	7.09
15. Singhat	22,130	22,130	-	0.29	0.42	-
16. Nambol	61,882	37,640	24,242	0.82	0.71	1.10
17. Bishnupur	62,778	37,533	25,245	0.83	0.71	1.15
18. Moirang	1,12,739	74,721	38,018	1.50	1.40	1.73
19. Lilong	87,377	58,628	28,749	1.16	1.10	1.31
20. Thoubal	1,99,310	1,25,375	73,935	2.65	2.35	3.37
21. Kakching	1,35,481	86,832	48,649	1.80	1.63	2.21
22. Lamshang	84,856	71,661	13,195	1.13	1.35	0.60
23. Patsoi	70,665	49,190	21,475	0.94	0.92	0.98
24. Lamphelpat	2,21,422	9,723	2,11,699	0.285	0.18	9.64
25. Wangoi	1,41,049	64,539	76,510	1.876	1.21	3.48
26. Jiribam	43,838	36,495	7,343	0.58	0.68	0.33
27. Sawombung	86,162	81,561	4,601	1.15	1.53	0.21
28. Porompat	2,44,089	83,582	1,60,507	3.25	1.57	7.31
29. Keirao Bitra	82,024	71,268	10,756	1.09	1.34	0.49
30. Ukhrul North	31,004	31,004	-	0.41	0.58	-
31. Ukhrul Central	1,07,378	80,191	27,187	1.43	1.51	1.24
32. Kamjong Chassad	16,717	16,717	-	0.22	0.31	-
33.Phungyar-Phaisat	16,539	16,539	-	0.22	0.31	-
34. Ukhrul South	12,360	12,360	-	0.16	0.23	-
35. Machi	19,865	19,865	-	0.26	0.37	-
36. Tengnoupal	39,245	22,398	16,847	0.52	0.42	0.77
37. Chandel	32,133	32,133	-	0.43	0.60	-
38. Chakpikarong	52,939	52,939	-	0.70	0.995	-
40. Manipur	2,855,794	2,021,640	834,154			

Source : *Data from Census of India, Primary Census Abstract, Manipur Series 15, 2011 and Concentration index has been computed by author.*

In case of urban population distribution results, location quotient and index of concentration are same. Both indicate that Lamphelpat, Porompat, Wangoi, and Thoubal etc. have higher degree of concentration of urban population in the state.

Distribution Pattern

Population potential is the best method to show the distribution pattern with the help of the total population of a place and distance can be calculated. The population potential of different places of the state through which can be drawn the potential lines and then a complete population potential map emerges for the study. Population potential values of Manipur shows the equi-potential lines of 300 for the Kamjong Chassad, Singhat, Tipaimukh and Thanlon as the lowest, and of 50,000 for Porompat and Lamphelpat which is the highest in the state. Network of equi-potential lines of Manipur very clearly shows the distributional pattern of population (Fig. 2).

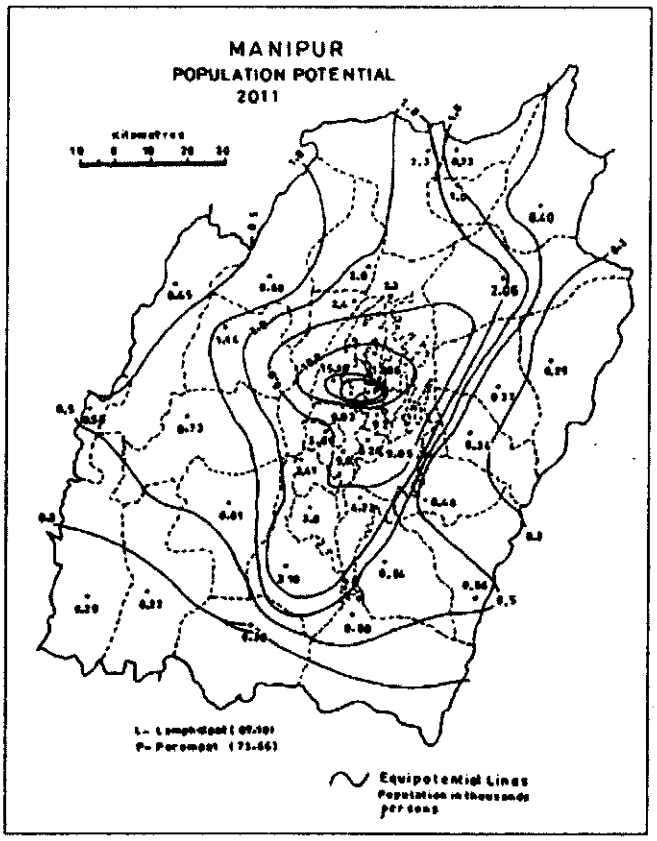

Fig. 2

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In Manipur, the highest population concentration is found in Porompat and Lamphelpat sub- divisions. In these sub- divisions concentration is higher than 2,00,000 persons. The area of concentration between 10,000- 15,000 persons are only in the sub- division of Lamshang. The areas of Patsoi, Wangoi, Lilong, Keirao- Bitra and Thoubal have population concentration variations from 5,000 to 10,000 persons. The sub- divisions of Ukhrul Central, Sadar Hills West, Sadar Hills East, Saitu- Gamphazol, Nambol, Bishnupur, Moirang, Churachandpur and Kakching have been the equi-potential lines between 2,000-5,000 persons. The only two sub- divisions of Purul and Tamenglong have been the equi-potential lines of 1,000-2,000 persons.

Apart from the central region of the state the equi-potential lines of less than 1,000 is in most western sub- divisions and some part of south eastern and Paomata and Purul sub-divisions in the northern part of the state. On the other hands, the sub- divisions of Lamphelpat and Porompat have a developed transport system and administrative centre, the growth of urban structures, administrative set-up, SSI units, and other infrastructural set ups have not been made significantly, but they have high population potentials. The satellite urban centers of Imphal and other rural service centers in the state have high population potential. The greatest potentiality of population has been found in Imphal, because of its high capability to absorbe rural population due to socio-economic betterment and employment opportunity, as Imphal is the state capital of Manipur and two districts head quarters of Imphal East and Imphal West at Porompat and Lamphel pat within its jurisdiction.

Conclusion

Results of location quotient, index of concentration and population potential have clearly revealed that distribution pattern of population in the state varies in different locations of the state. The central valley or the inner portion of the state is highly populated. In the remote parts of the state, viz. the Tamenglong sub-division has a moderate population concentration; and the southern in Churachandpur district and a small belt of eastern areas of Chandel and Ukhrul districts, have less concentration of population distribution.

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PLANT PARASITIC NEMATODES ASSOCIATED WITH MEDICINAL PLANTS IN MANIPUR PART II: THE SPECIES OF THE GENUS Helicotylenchus

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Abstract

A survey was carried out for plant parasitic nematodes associated with medicinal plants of Manipur. Soil samples were collected from the rhizosphere of medicinal plants and nematodes were isolated by Cobb's sieving and decanting method follwed by modified Baermann's funnel technique. Ten species of nematodes belonging to the genus *Helicotylenchus* were recorded.

Key words : Plant parasitic nematodes, medicinal plants, *Helicotylenchus*, species, rhizosphere

Introduction

Medicinal plants are one of the economically important plant groups. These plants are affected by varied types of pests and diseases including phytonematode species. Among the agents that affect plants, phytonematodes are one important group that disturb the plant. Due to their infestations the plants become unhealthy having stunted growth and reducing the yield, sometimes damaging the whole plant, but the informations concerning the infestations of plant parasitic nematodes to medicinal plants is scarce. However some workers like Sultan and Jairajpuri (1979), Dhanachand and Jairajpuri (1980), Gambhir and Dhanachand (1996), Romabati and Mohilal (2012), Uma and Romabati (2014) reported the common plant parasitic nematodes from Manipur. The present investigation was carried out on the occurrence of the species of plant parasitic nematode under the genus *Helicotylechus* associated with different medicinal plants of Manipur during 2010-2011.

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Materials and Methodes

Nematode sample from different localities of Manipur were collected from rhizosphere of different medicinal plants and soil upto the depth of 30-60 cm. The collected soil samples were processed for extraction of nematodes by Cobb's sieving and decanting method followed by modified Baermann's funnel technique (Thorne, 1961). The collected nematode species were killed and fixed in warm F.A (4:1) and then mounted in anhydrous glycerine.

Results and Discussion

Ten known species of plant parasitic nematode under the genus *Helicotylenchus* namely *Hecotylenchus bihari, H. digitatus, H. digonicus, H. dihystera, H. erythrinae, H. exallus, H. indicus, H. multicintus, H. pseudorobustus and H. rotundicauda* were recorded. Measurements and localities are presented.

Helicotylenchus bihari Mulk and Jairajpuri, 1974

Females (8) : L = 0.52-0.56 (0.53) mm; a = 15.0-20.0 (16.5); b= 5.0-5.5 (5.5); c = 33.0-40.0 (36.5); G_1 = 31.5-35.5 (33.5); G_2 = 23.5-28.5 (26.5); V = 60.0-62.5 (61.5); stylet = 20.0-21.5 (20.5) µm; lip annules = 5; oesophageal length = 140.0-147.0 (143.0) µm from anterior end; tail = 14.5-16.0 (15.5) µm; phasmid = 3 annules posterior to anus.

Male : Not found.

Habitat and Locality : Soil around the roots of *Prunus persica* (L.) Batsch. from Kangchup, Imphal West District, *Cynodon dactylon* (L.) Pers. From Sendra, Bishenpur District.

Remarks : The present specimens have been identified as *Helicotylenchus bihari* because they have similar body length, stylet length, tail shape covex and truncate with distinct annulations and other morphological characters.

Helicotylenchus digitatus Siddiqi and Hussain, 1964

Females (1) : L = 0.67; b = 4.5; c = 27.0; V = 63.5; G_1 = 27.5; G_2 = 26.0 ; stylet = 23.0 µm; lip annules = 4; oesophageal length = 182.0 µm from anterior end; tail = 24.5 µm, phasmid = 2 annules posterior to anus.

Male : Not found.

Habitat and Locality : Soil around the roots of *Rhus succedenea* L. From Pheiyeng, Imphal West District.

Remarks : The present specimens similar with the measurement and morphology described by Siddiqi and Hussain (1964) except for body length and stylet length. These differences may be intraspecific variations.

Helitylenchus digonicus Perry, 1959

Females (16) : L. = 0.42-0.54 (0.48) mm; a = 16.0-17.5 (16.7); b = 4.0-4.9 (4.4); c = 42.2-52.7 (47.4); V =68.3-82.7 (76.3); G1 = 16.1-40.2 (35.4); G2 = 20.0-24.5 (22.5); stylet = 20.8-24.0 (22.4) µm; lip annules = 4; oesophageal length = 147.0-182.5 (165.5) µm from anterior end; taii = 8.0-12.5 (10.0) µm long; phasmid = 7 annules anterior to anus.

Male ; Not found.

Habitat and Locality : Soil around roots of *Psidium guajava* L. From Lairenjam, *Canna indica* L. Keishamthong, *Dactyloctenium aegyptium* (L.) P. Beauv. from Pangei, Imphal East District, *Artocarpus integera* (Thumb.) from Komlathabi, Chandel District.

Remarks : In comparison with the original description, the present specimens are within the range of *H. digonicus* except slightly smaller body length, little shorter stylet and posteriorly located vulva and it also conform to all the dimensions and morphplogical character given by Anderson (1974).

Helicotylenchus dihystera (Cobb,1893) Sher, 1961

Females (30) : L =0.58-0.63 (0.60); a = 22.0-30.5 (26.5); b = 4.5-5.5 (5.0); c = 37.5- 45.6 (41.5); V = 62.5-69.0 (65.5); G_1 = 21.5- 29.0 (24.5); G_2 = 16.0-26.5 (22.5); stylet = 20.0-21.5 (21.0) µm; oesophageal length = 136.0-152.0 (144.5) µm from anterior end; tail = 12.5-16.5 (15.0) µm; phasmid = 3 annules anterior to anus.

Male (5) : L = 61-0.64 (0.62) mm; a = 23-27 (25); b = 4.5-5.5 (5.0); c = 13.5-14.0 (13.5); T = 59.5 -60.0 (59.5); stylet = 16.0-16.5 (16.5) µm; spicule = 24.5-25.5 (25.0) µm; gubernaculum = 11.0-12.0 (11.5) µm; bursa = 62.5-64.0 (63.0) µm; tail = 43.0-46.5 (44.0) µm.

Habitat and Locality : Soil around the roots of *Eupatorium birmanicum* DC. and *Leucas aspera* (L.) R. Br. Ex. Valke from Ningomthongjao, Sagoltongba, Imphal West District, *Cynodon dactylon* (L.) Pers. From Sekmai, Imphal West District, Naranseina, Nambol, Thanga, Bishenpur district, *Centella asiatica* (L.) Urban from Thoubal Sabaltongba, Thoubal District.

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Remarks : *Helicotylenchus dihystera* is widely distributed in Manipur. Specimens of this population conform to the characters of *H. dihystera* (Cobb,1893) Sher, 1961. However there is the slightly variations in the stylet length, spicule and gubernaculum and these are considered as intraspecific variations.

Helicotylenchus erythrinae (Zimmermann, 1940) Golden, 1960

Females (5) : L =0.45-0.62 (0.54) mm; a = 25-31 (27); b = 5.0-6.5 (5.5); c = 34.0-42.0 (37.5); V = 51.0-60.0 (55.5); G_1 = 20.0-23.0 (22.0); G_2 = 21.0-2.05 (23.0); stylet = 25.0-28.0 (26.5) µm; lip annules = 3-4 ; oesophageal length = 110.0-122.0 (118.5) µm from anterior end; tail = 12.5-16.5 (14.5) µm; phasmid = 1-3 annules anterior to anus.

Males : Not found.

Habitat and Locality : Soil around the roots of *Erythrina stricta* Roxb. from Kumbi, Oinam, Bishenpur District.

Remarks : The present specimens conform to all dimensions and morphological characters given by Sher (1966).

Helicotylenchus exallus Sher,1966

Females (23) ; L = 0.61-0.66 (0.63) mm; a = 21.5-24.0 (22.5); b = 5.5-6.0 (5.5); c =40.5-51.0 (46.0); V = 65.0-67.0 (66.0); G_1 = 19.5-22.5 (21.0); G_2 = 17.0-19.5 (18.0); stylet =20.0-22.5 (21.0) µm; lip annules = 4-5; oesophageal length = 132.5-155.0 (143.0) µm; tail = 120-16.0 (14.5) µm from anterior end; phasmid = 6-8 annules anterior to anus.

Male : Not found.

Habtat and Locality : Soil around the roots of *Cannabis sativa* L. from Khonghampat, *Carica papaya* L. from Kangchup, *Solanum melongana* L. from Singjamei, Imphal West District.

Remarks : Morphology and measurements of the present specimens agree with most of the dimensions and characters of those given by Sher (1966) except that these specimens have slightly shorter stylet and little greater value of c.

Helicotylenchus indicus Siddiqi, 1963

Females (22) : L = 0.50-0.56 (0.53) mm; a = 25.0-31.0 (28.5); b =5.0-6.0 (5.5); c =28.0-36.0 (33.0); V = 58.0-63.0 (60.5); G1 = 17.0-20.0 (18.0); G2= 14.0-17.0 (15.5); stylet = 20.0-21.5 (20.5) µm; lip annules = 4-5; oesophageal length = 130.0-138.0 (134.5) µm from anterior end; tail = 16.5-20.5 (18.5) µm; phasmid = 4 annules anterior to anus.

Male : Not found.

Habitat and Locality : Soil ariund the roots of *Mentha arvensis* L., *Mimosa pudica* L. *Amaranthus spinosus* L. From Langjing Achouba, Singjamei Kshetri Leikai, Imphal West District, Andro Khonou, Keirao , Imphal East District, *Annona reticulata* L., *Cucurbita hispida* Thunb. From Parbung Churachandpur District, *Amorphophallus campanulatus* Bl. Ex. Dience. From Oinamlong, Tamenglong District.

Remarks : The dimensions of the present specimens are within the range of measurements of *H. indicus* Siddiqi (1963) and are also similar with those described by Sher (1966).

Helicotylenchus multicintus (Cobb,1963) Golden, 1956

Females (8) : L = 0.40-0.58 (0.49) mm; a = 26.0-29.0 (27.5); b = 4.8- 5.2 (5.0); c = 38.0-45.0 (41.5); V = 65.0-70.0 (67.5); G_1 = 26.0-27.5 (26.5); G_2 = 18.0-21.0 (19.0); stylet = 23.0-24.0 (23.5) µm; lip annules = 5-6; oesophageal length = 128.0-136.8 (132.5) µm from anterior end; tail =20.0-22.5 (21.5) µm; phasmid = 5-6 annules anterior to anus.

Male : Not found.

Remarks : Specimens of this population conform to the characters of *H. multicintus* given by Sher (1966).

Helicotylenchus pseudorobustus (Steiner,1914) Golden, 1956

Females (5) : L =0.51-0.55 (0.53) mm; a = 23.0-24.0 (23.5); b = 5.0-5.5 (5.5); c = 25.0-30.0 (27.0); V = 64.0-67.0 (65.5); G_1 = 29.0-39.0 (28.5); G_2 = 27.5-29.0 (28.5); stylet = 24.0-26.0 (25.0) µm; lip annules = 4; oesophageal length = 124.0-125.5 (124.5) µm from anterior end; tail = 10.5-16.5 (14.5) µm phasmid = 5-7 annules anterior to anus.

Male : Not found.

Habitat and Locality : Soil around the roots of *Ananas comosus* (L.) Merr. From Waithou, Thoubal District, Kangpokpi, Senapati District.

Remarks : The present specimens agree with most of the dimensions of those described by Sher (1966) except little shorter body length.

Helicotylenchus rotundicauda Sher, 1966

Females (20) : L = 0.56-0.67 (0.62) mm; a = 25.0-26.0 (25.5); b = 5.5-6.0 (5.5); c = 38.5-43.5 (40.5); V = 62.0-66.0 (63.5); G_1 = 27.5-29.5 (28.5); G_2 = 19.5-24.5 (21.5); stylet = 24.0-25.0 (24.5) µm; oesophageal length = 126.5-134.5 (130.0) µm from anterior end; tail = 14.5-16.0 (15.5) µm; phasmid = 7 annules anterior to anus.

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Male : Not found.

Habitat and Locality : Soil around the roots of *Centella asiatica* (L.) Urban from Andro,Imphal East district, Langthabal, Lamshang, Imphal West District, *Cynodon dactylon* (L.) Pers. Tentha, Icham Khunou, Thoubal District.

Remarks : The dimensions of the presnt specimens are within the range of measurement and conform well with the descriptions given by Sher (1966) except that these specimens have slightly shorter body length and anteriorly located excretory pore.

Helicotylenchus species are one of the ectoparasitic nematode and hidden enemies of plants. These nematode penetrate and feed on the roots of growing plants exposing the affected root to other pathogenic microorganisms causing loss of yeild of the plant. The present work on the plant parasitic nematode invading the medicinal plants will provide the information of the phytonematodes that will help to control the plants for more productivity.

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BRIGHT AND DARK SOLITON SOLUTIONS OF HIGHER - ORDER NONLINEAR SCHRODINGER EQUATION VIA THE ANSATZ APPROACH

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Abstract

In this paper, the ansatz approach is being used to construct analytical Bright and Dark Soliton solutions of the Higher – Order Nonlinear Schrodinger equation that can model the femtosecond and ultra-short (few cycle) optical pulse propagation in optical fibers.

Keywords : Bright and Dark Solitons, Ansatz approach, Higher – Order Nonlinear Schrodinger Equation, optical fibers.
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MSC(2010) Nos.: 35Q55, 35Q94, 37K40.

1. Introduction :

Basically, a soliton is a wave having a single crest. They result when waves' natural tendency to spread during propagation is cancelled out by an inherently nonlinear phenomenon known as self- focusing. They can travel long distances with undistorted shape. A bright (or non-topological) soliton is characterized as a localized intensity peak above a continuous wave background whilst a dark (or topological) soliton is featured as a localized intensity dip below a continuous wave background. It is well known that during the last a few decades, optical solitons have attracted much attention in the high capacity optical fiber communication systems [Ablowitz et al. 1981, Ablowitz et al. 1991, Agarwal 1989, Hasegawa, 1989, Hasegawa et al. 1995,] because of their unique property of long distance propagation without distortion and spreading. The nonlinear Schrodinger equation (NLSE) is used to model the propagation of picosecond optical pulses in optical fibers and is of fundamental importance in optical fiber communication [Ablowitz et al. 1991, Agarwal 1989, Hasegawa et al 1973, Mollenauer et al. 1990,]. The

NLSE with group velocity dispersion (GVD) and self- phase modulation (SPM) is a relatively simple soliton equation (equation having soliton solution) and is completely integrable via the methods of inverse scattering transform (IST), Painleve analysis, bilinear transformation etc.

However, in the regime of femtosecond optical pulses and of ultra-short (few cycle) optical pulses, a lot of experimental as well as theoretical works had shown the inadequacy of the NLSE. In order to model the propagation of such much shorter optical pulses, additional terms of third order and nonlinear dispersion terms were to be added to the NLSE. Subsequently, the higher-order nonlinear Schrodinger equation (HONLSE) [Kodama, 1985, Kodama et al. 1987, Narayansami,2006, taghizadeh et al. 2014] was put forward in the form

$$u_z = ia_1 u_{tt} + ia_2\, u|u|^2 + a_3 u_{ttt} + a_4(u|u|^2)_t + a_5\, u(|u|^2)_t \qquad (1)$$

where $u = u(z,t)$ stands for a slowly varying envelope of electric field, z and t are the spatial and temporal variables in a retarded co-ordinate system, the subscripts denote partial derivatives with respect to each of them, the quantities a_j (j = 1,2,3,4,5) are real parameters respectively related to the group velocity dispersion (GVD), self- phase modulation (SPM), third order dispersion (TOD), self- steepening (SS) and self-frequency shift (SFS) arriving from Stimulated Raman Scattering (SRS) and

i is the imaginary number equal to $\sqrt{-1}$ ..

The structure of the paper is arranged as in the following. In Section 2, a brief algorithm of the ansatz approach is presented, in Section 3, the approach is employed in finding the Bright and the Dark soliton solutions of the HONLSE. In Section 4, a brief conclusion is presented.

2. Algorithm of Ansatz Method:

Let us suppose that we have to solve a partial differential equation (PDE) that can be expressed in the form

$$P(u, u_z, u_t, u_{zz}, u_{zt}, u_{tt} \quad \ldots) = 0 \qquad (2)$$

where P is a polynomial in its arguments, u is a function of the independent variables z, t and the subscripts denote partial derivatives with respect to each of them.

We introduce a new variable $\xi = t + \gamma z$ where γ is a parameter to be determined latter and we make a transformation

$$u(z,t) = U(\xi)$$

Then eq.(2) can be written as an ordinary differential equation (ODE) in the form

$$Q(U, U', U'', U''', \ldots) = 0 \qquad (3)$$

where $U' = \frac{dU(\xi)}{d\xi}$, $U'' = \frac{d^2U(\xi)}{d\xi^2}$, etc.

Then solving eq.(3) and hence eq.(2), we can obtain the solution of eq.(1).

If a given equation contains terms with complex functions or variables and if it has a soliton solution, we have to introduce the transformations

$u(z,t) = U(\xi) = f(\xi)\, e^{i\phi}$ (4)

with $\xi = t + \gamma z$ (5)

and $\phi = kz - \omega t$ (6)

where the parameter γ is the reciprocal of the soliton speed, the parameters k and ω are respectively the propagation number and the circular frequency of the soliton in the retarded co-ordinate system.

(i) Bright (non-topological) soliton solution : For bright soliton solution, we assume the function $f(\xi)$ in the form

$$f(\xi) = A\, sech^p B\xi$$

with $\xi = t + \gamma z$ where γ is the reciprocal of soliton speed, A and B are respectively the amplitude and the inverse width of the soliton and p is a parameter to be determined latter.

Then, substitution of this function $f(\xi)$ into eq. (4) , then the resulting function into eq. (2) and also the determination of the parametric values will give a bright soliton solution of eq. (2).

(ii) Dark (topological) soliton Solution: For dark soliton solution, we assume the function $f(\xi)$ in the form

$$f(\xi) = A\, tanh^p B\xi$$

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with $\xi = t + yz$ where y, A, B, and p are parameters similar to those stated in the case of bright soliton solution . Then, the substitution of this function $f(\xi)$ into eq. (4), then the resulting function into eq. (2) and also the determination of the parametric values will give a dark soliton solution of eq.(2).

3. Application of the ansatz approach to HONLSE:

In this Section, we apply the ansatz method to solve eq.(1) and then the bright and the dark soliton solutions of the equation are obtained.

Using eq.(4), we obtain,

$$u_z = [\gamma f'(\xi) + ikf(\xi)]\, e^{i\phi} \quad , \tag{7a}$$

$$u_{tt} = [f''(\xi) - 2i\omega f'(\xi) - \omega^2 f(\xi)]\, e^{i\phi} \quad , \tag{7b}$$

$$u\,|u|^2 = f^3(\xi)\, e^{i\phi} \, , \tag{7c}$$

$$u_{ttt} = [f'''(\xi) - 3i\omega f''(\xi) - 3\omega^2 f'(\xi) + i\omega^3 f(\xi)]\, e^{i\phi} \, , \tag{7d}$$

$$(u\,|u|^2)_t = [3f^2(\xi)f'(\xi) - i\omega f^3(\xi)]\, e^{i\phi} \, , \tag{7e}$$

$$u\,(|u|^2)_t = 2f^2(\xi)f'(\xi)e^{i\phi} \, . \tag{7f}$$

Using eqs. (4) to (7) we can write eq.(1) as

$$\gamma f'(\xi) + ikf(\xi) = ia_1 f''(\xi) + 2\omega a_1 f'(\xi) - i\omega^2 a_1 f(\xi) + ia_2 f^3(\xi) + a_3 f'''(\xi)$$
$$-3i\omega a_3 f''(\xi) - 3\omega^2 a_3 f'(\xi) + i\omega^3 a_3 f(\xi) + 3a_4 f^2(\xi)f'(\xi) - i\omega a_4 f^3(\xi)$$
$$+ 2a_5 f^2(\xi)f'(\xi) = 0 \, . \tag{8}$$

Separation of eq.(8) into real and imaginary parts yields

Real Part:

$$a_3 f'''(\xi) - (\gamma - 2a_1\omega + 3a_3\omega^2)f'(\xi) + (3a_4 + 2a_5)f^2(\xi)f'(\xi) = 0. \tag{9}$$

Imaginary Part:

$$(a_1 - 3a_3\omega)f''(\xi) - (k + a_1\omega^2 - a_3\omega^3)f(\xi) + (a_2 - a_4\omega)f^3(\xi)\,0. \tag{10}$$

Integrating eq.(9) once with respect to ξ and choosing the integration constant as zero, we obtain

$$a_3 f''(\xi) - (\gamma - 2a_1\omega + 3a_3\omega^2)f(\xi) + \tfrac{1}{3}(3a_4 + 2a_5)\, f^3(\xi) = 0. \tag{11}$$

The necessary and sufficient condition that a non-constant function $f(\xi)$ satisfy both the eqs. (10) and (11) is that there must exist the following constraint conditions.

$$\frac{a_1-3a_3\omega}{a_3} = \frac{k+a_1\omega^2-a_3\omega^3}{\gamma-2a_1\omega+3a_3\omega^2} = \frac{3(a_2-a_4\omega)}{3a_4+2a_5}. \quad (12)$$

Solving the system of eqs. (12) with *Mathematica* 9, we obtain

$$\omega = \frac{3a_1a_4+2a_1a_5-3a_2a_3}{6a_3(a_4+a_5)}, \quad (13)$$

$$k = \frac{a_1}{a_3}\gamma - \left(3\gamma + 2\frac{a_1^2}{a_3}\right)\omega + 8a_1\omega^2 - 8a_3\omega^3. \quad (14)$$

Then, the bright and the dark soliton solutions of HONLSE are separately obtained as detailed below.

3.1. Bright (non-topological) soliton:

To obtain bright soliton solution of HONLSE , the function $f(\xi)$ appeared in eq.(11) is assumed to have the form

$$f(\xi) = A\, sech^p(B\xi) \quad (15)$$

where A is the amplitude and B is the inverse width of the soliton, p is a number unknown at the present stage but to be determined latter and ξ is already defined earlier. Now, we have,

$$f''(\xi) = p^2AB^2sech^p(B\xi) - p(p+1)AB^2sech^{p+2}(B\xi). \quad (16)$$

Substitution of eqs.(15) and (16) into eq.(11) results in

$$a_3p^2\,B^2sech^p(B\xi) - a_3p(p+1)\,B^2sech^{p+2}(B\xi) - (\gamma - 2a_1\omega + 3a_3\omega^2)\,sech^p(B\xi)$$

$$+\frac{1}{3}(3a_4 + 2a_5)A^2sech^{3p}(B\xi) = 0. \quad (17)$$

From eq.(17), equating the exponents $p+2$ and $3p$, we obtain,

$$p = 1. \quad (18)$$

From eq(17), equating the coefficient of $sech^3(B\xi)$ to zero, we obtain,

$$(3a_4 + 2a_5)\,A^2 - 6A_3B^2 = 0. \quad (19)$$

Further, from eq.(17), equating the coefficient of

$$a_3B^2 - (\gamma - 2a_1\omega + 3a_3\omega^2) = 0. \quad (20)$$

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Solving the simultaneous eqs.(19) and (20), we obtain, $\mathrm{sech}(B\xi)$ to zero, we obtain,

$$A = \pm \sqrt{\frac{6(\gamma - 2a_1\omega + 3a_3\omega^2)}{3a_4 + 2a_5}}, \tag{21}$$

$$B = \pm \sqrt{\frac{\gamma - 2a_1\omega + 3a_3\omega^2}{a_3}}. \tag{22}$$

Substitution of eqs(15), (18), (21) and (22) into eq.(4) yields a bright soliton solution of eq.(1) in the form

$$u(z,t) = \sqrt{\frac{6(\gamma - 2a_1\omega + 3a_3\omega^2)}{3a_4 + 2a_5}} \ \mathrm{sech}\left[\sqrt{\frac{\gamma - 2a_1\omega + 3a_3\omega^2}{a_3}}\ (t + \gamma z)\right] \times e^{i\left[\left\{\frac{a_1}{a_3}\gamma - \left(\frac{3\gamma a_3 + 2a_1^2}{a_3}\right)\omega + 8a_1\omega^2 - 8a_3\omega^2\right\}z - \left\{\frac{3a_1a_4 + 2a_1a_5 - 3a_2a_3}{6a_3(a_4 + a_5)}\right\}t\right]}. \tag{23}$$

It is seen that the result obtained here is in agreement with that reported by *Taghizadeh et al*.

In figure 1, a profile of bright soliton intensity for $\gamma = a_1 = a_4 = a_5 = 1$, $a_2 = a_3 = 0.5$, $\omega = 0.708$, $A = 0.629$ and $B = 0.82$ is shown.

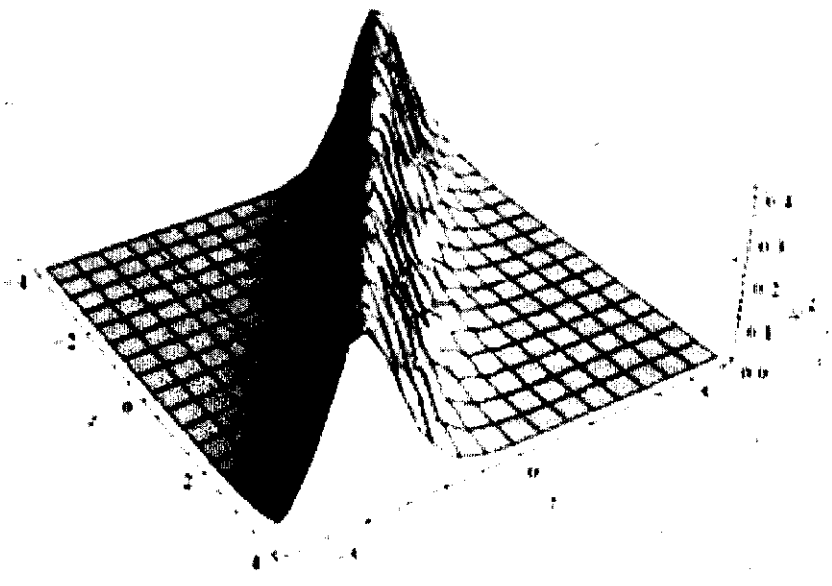

Figure 1. Intensity profile of bright soliton with the specifications stated above.

3.2. Dark (topological) Soliton:

To obtain the dark soliton, the function $f(\xi)$ appeared in eq. (11) is assumed to have the form

$$f(\xi) = A\, tanh^p(B\xi) \tag{24}$$

where the parameters A, B and p are quantities similar to those stated in the case of bright soliton.

Now, we have,

$$f''(\xi) = A\,B^2p(p-1)tanh^{p-2}(B\xi) - 2AB^2p^2\, tanh^p(B\xi) + AB^2p(p+1)tanh^{p+2}(B\xi). \tag{25}$$

Substitution of eqs.(24) and (25) into eq.(11) yields

$$a_3[AB^2p(p-1)tanh^{p-2}(B\xi) - 2AB^2p^2tanh^p(B\xi) - AB^2p(p+1)tanh^{p+2}(B\xi)]$$
$$-(\gamma - 2a_1\omega + 3a_3\omega^2)A\, tanh^p(B\xi) + \frac{1}{3}(3a_4 + 2a_5)A^3tanh^{3p}(B\xi) = 0\,. \tag{26}$$

From eq.(26), equating the exponents $p + 2$ and $3p$, we obtain

$$p = 1. \tag{27}$$

Again, from eq.(26), equating the coefficient of $tanh^3(B\xi)$ to zero, we obtain

$$(3a_4 + 2a_5)\,A^2 - 6a_3\,B^2 = 0. \tag{28}$$

Further, from eq.(26), equating the coefficient of tanh $(B\xi)$ to zero, we obtain

$$2B^2 + (\gamma - 2a_1\omega + 3a_3\omega^2) = 0. \tag{29}$$

Solving the simultaneous eqs.(28) and (29), we obtain

$$A = \pm \sqrt{\frac{3(-\gamma a_3 + 2a_1a_3\omega - 3a_3^2\omega^2)}{3a_4+2a_5}}\,, \tag{30}$$

$$B = \pm \sqrt{\frac{-\gamma + 2a_1\omega - 3a_3\omega^2}{2}}\,. \tag{31}$$

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Substitution of eqs.(24), (27), (30) and (31) into eq.(4) yields a dark soliton solution of eq.(1) in the form

$$u(z,t) = \sqrt{\frac{3(-\gamma a_3 + 2a_1 a_3 \omega - 3a_3^2\omega^2)}{3a_4 + 2a_5}} \tanh\left[\sqrt{\frac{-\gamma + 2a_1\omega - 3a_3\omega^2}{2}}\ (t + \gamma z)\right]$$

$$\times\ e^{i\left[\left\{\frac{a_1}{a_3}\gamma - \frac{1}{a_3}(3\gamma a_3 + 2a_1^2)\omega + 8a_1\omega^2 - 8a_3\omega^3\right\}z - \left\{\frac{3a_1a_4 + 2a_1a_5 - 3a_2a_3}{6a_3(a_4+a_5)}\right\}t\right]} \quad . \quad (32)$$

In figure 2, the profile of a dark soliton intensity for $\gamma = a_2 = a_3 = 0.5$, $a_1 = a_4 = a_5 = 1$, $\omega = 0.7083$, $A = 0.2218$ and $B = 0.2864$ is shown

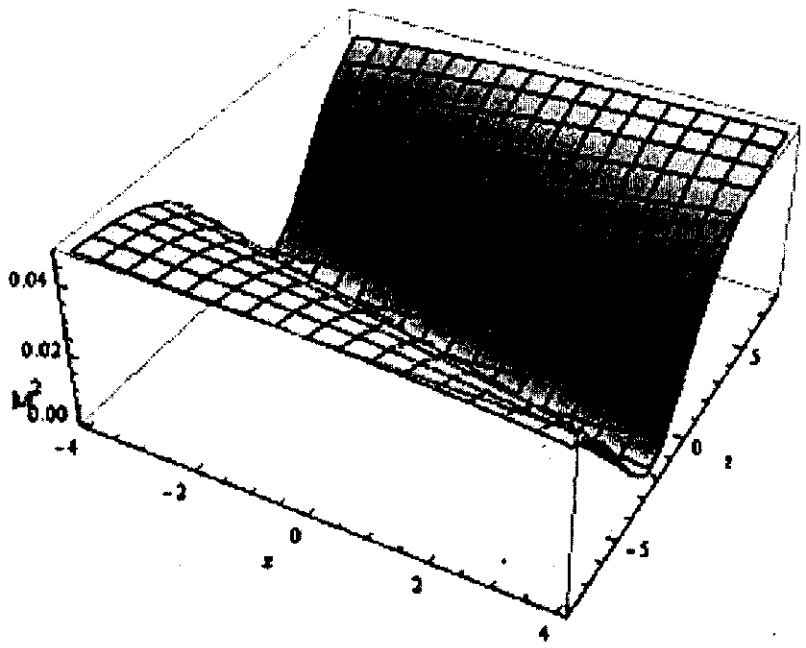

Figure 2. Intensity profile of dark soliton with the specifications stated above.

4. Conclusion.

In this paper, the ansatz method of finding soliton solutions of HONLSE has been studied and the results show that this method is a powerful tool for obtaining exact solutions of many nonlinear evolution equations appearing in nonlinear sciences and engineering.

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ROLE OF MANIPURIS IN THE NINETEENTH CENTURY CACHAR

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In the history of nineteenth century Cachar (now in Assam, India), Manipuris played a great role not only in the politics but also in the economy and society too. During the First Anglo-Burmese War (1824-1826), the Manipuris living in the region assisted the British in expelling the Burmese from the soil of Cachar. They also took a lion's share in developing the economy of Cachar by expanding and improving cultivable land of the valley. When the Manipuris of Cachar played a great role in the expansion of its agricultural land by defending against the Kuki headhunting raids, Lt. Fisher, incharge of Cachar, reported: "A great extension of cultivation and consequent increase of revenue may be expected from it not merely from the land which will be cleared by the Munnipoorees but from much large tracks which will be protected by them and which in their present state of insecurity our unwarlike Ryuts are afraid to occupy."[1]

On the high hopes of Lt. Fisher, H.K. Barpujari writes in *Assam in the Days of the Company*, "He had had great hopes to the revenue of Cachar, but to his utter disappointment, Fisher found in the first year of occupation that the receipt could barely meet the charge on the establishment..."[2] On the same area of study, Sir Edward Gait writes in *A history of Assam*, "His (Lt. Fisher) first care was to cope with the eruption of the Kukis. This he did by the expedient of settling along the frontier as many Manipuris as possible, who, when supplied with a few firearms, easily kept off the Kukis, and so protected, not only themselves, but also the less warlike plainsmen behind them."[3] But, so far, no scholar has tried to highlight a clear socio-economic and political role of the Manipuris in Cachar in its historic perspectives. This paper is, therefore, to fill up the missing part of the history of Cachar in northeast India. The source materials are archival,

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oral as well as secondary source books. The method applied is qualitative involving both exploratory and interpretative parts.

Historical background of Manipuris in Cachar

Apparently, Manipuris had been developing a close relationship with the Cacharis from the seventeenth century A.D. In this regard, Gangmumei Kabui writes: "One girl from Manipur was married to a chief of Kacharis. In June, 1670 the bride price of the girl named Mayangleima was given in a form of a palanquin. The name of this girl was Keisham Chanu Tangkhonbi."[4] Besides, Cachar had been the main outlet of the Manipuris towards west and, thus, they time and again took shelter and settled down permanently in this region whenever there was any political unrest in Manipur. When Manipur was under Raja Garibaniwaza (1709-1748), a great mass of Manpuris left Manipur and settled down in Cachar. Regarding it, the *Ningshing Chephong* mentions that some people had to leave Manipur and settle down as they were expelled by the king for their refusal to accept Vaishnavism.[5] After the death of Raja Garibaniwaza, the Burmese became very powerful and, thus, invaded Manipur repeatedly. Consequently, the Rajas and the Princes of Manipur, along with their subjects, had to make their settlements in Cachar in large number during the period 1809-1819.[6] Above all Raja Krishnachandra of Cachar married the Manipuri princess Induprabha. Consequently, Parbitta Singh, brother of princess Induprabha, settled down in Cachar. Upendra Guha, in his Cacharer Itibritta, writes, "There was close ties between Manipur and Kachari kings when the latter was ruling from Khaspur. With the betrothal of princess Induprabha (daughter of Raja Madhuchandra of Manipur) to Kachari king Krishnachandra (1780-1813) Manipuri settlements in Cachar enhanced."[7] In 1813, Marjit Singh of Manipur, with the help of the Burmese king, expelled his brother Raja Chourjit Singh, and the latter went to Cachar with his brother Gambhir Singh. Later, in 1819, when Manipur was occupied by the Burmese, Raja Marjit Singh along with thousands of Manipuris went to Cachar and settled down there. They, then, started to play their role in the socio-economic and political affairs of the region.

Manipuris in the politics of Cachar

Raja Chourjit Singh, coming to Cachar in 1813, applied to Govindchandra (brother of Krishnachandra) for assistance against Marjit Singh. Being refused, Chourjit Singh went to Calcutta, there also, being helpless, he came to Jaintia and made an alliance

with Ram Singh. Gambhir Singh, living in Cachar with his followers, joined the service of Raja Gobindchandra (1813-1830). J.B. Bhattacharjee writes that Govindchandra appointed Gambhir Singh as the Commander-in-Chief of the Cachar Army at a monthly salary of Rs. 50.[8] Meanwhile, Cachar was invaded by Raja Marjit Singh of Manipur in December 1817. Govindchandra sought the help of the British, but failed. At this juncture, Chourjit Singh and Gambhir Singh assisted the Cachar Raja and forced Marjit Singh to retreat to his own territory. Before the engagement, Chourjit Singh got the consent from Govindchandra to handover southern part of Cachar in the event of their success against Marjit Singh. Thus, from 1818, Chourjit Singh and Gambhir Singh had been ruling over some parts of south Cachar independently. Govindchandra's principality was saved for the time being, but he soon found that his friends were his worst enemies. Chourjit Singh, Gambhir Singh and Tularam (an enemy of Gobindchandra) took advantage of Govindchandra's troubles and plundered Cachar. Ultimately, the Cachar Raja was ousted from his Kingdom and compelled to take shelter at Sylhet, a British Division now in Bangladesh, and the Manipuris ruled over the whole south Cachar. Here, A.C. Banerjee writes, "Towards the middle of the year 1818 the Cachar Raja was ousted from his kingdom and compelled to take shelter at Sylhet."[9] Therefore, Chourjit Singh and Gambhir Singh started ruling over the entire south Cachar from 1818. In Manipur, Raja Marjit Singh failed to satisfy the expectations of the Burmese king and the latter, invading Manipur, expelled the former to Cachar in 1819 leading to the Seven Years Devastation of Manipur (1819-1825). It was the period during which thousands of Manipuris migrated to Cachar. After some time, the three Manipuri brothers living in Cachar reconciled and divided South Cachar for themselves. Gouri Sen writes, "These three Manipuri princes split the Kachari Kingdom into three divisions and each governed one part during 1819-1823 from three new capitals~ Gambhir Singh from Gumrah~ Marjit from Hailakandi~ and Chaurjit from Dungurirpar near Sonoimukh."[10] But in the beginning of 1823, a quarrel broke out among the three Manipuri brothers. Consequently, Marjit Singh occupied Hailakandi and Gambhir Singh possessed himself of the rest of south Cachar. Chourjit Singh left Cachar and took shelter at Sylhet in May 1823.

By December 1823, when Gambhir Singh was the virtual Raja of South Cachar, the Burmese not only occupied Assam and Manipur but also invaded Cachar from three directions viz. Assam, Jaintia and Manipur. The third Burmese party from Manipur arrived south Cachar and inflicted a defeat on the local levy of Raja Gambhir Singh.

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Consequently, the prince fled to Sylhet and started communicating with the British to face the Burmese aggression. At that juncture, the British Government also felt the great danger with which their frontier was threatened. They also thought of the bravery and warlike character of Manipuris who had been resisting the Burmese onslaughts for many years. On it, a report expressed, "The Munneepore country, which is inhabited by a brave and hardy race, who have frequently opposed a noble resistance to their Burmese invaders would thereby accrue to the security and tranquility of our North-East Frontier."[11] Again, in a letter to the Court of Directors, it was stated, "Under such an emergency it was natural that every resource, however trifling, should be sought after and the reestablishment of the Munnipore dynasty seems to have been a scheme peculiarly favoured by the late agent Mr. Scott."[12] Ultimately, it was accepted to join the British force by a group of Manipuris known as the Raja Gambhir Singh's Levy consisting of 500 infantry and 40 cavalrymen.[13] Lord Amherst, the then Governor General of British India, declared war against Burma on 5th march, 1824, and the Raja Gambhir Singh's Levy joined the British outpost at Badarpur (Cachar) in April of the same year. They were supplied with arms and their expenses were also borne by the British. However, they were irregulars as no pay was entitled to them.

By this time, the Burmese had built their strongholds at Talain Mountain, Jatrapur and Dudpatil in Cachar. Their number in those positions was estimated at about 8000. The British Army under Lt. Col. William Inns arrived at Badarpur on June 20 and then proceeded by water along the river Barak to Jatrapur where he arrived on June 27. On the way, with Gambhir Singh, he tried to dislodge the Burmese from the heights of Talain where the latter was strongly fortified. For three days (July 6, 7, 8) British guns fired on the stockade~ Gambhir Singh with his excellent local knowledge, assisted the operation.[14] In this battle, the Manipuris chased and captured Takheng Mitlao and Gun Singh (Manipuris) who were Burmese agents coming to arrest Chourjit Singh, Marjit Singh and Gambhir Singh (Manipuri brothers). Later, the two were killed by throwing into the water of the Barak River.[15] Towards the end of October 1824, the entire Burmese Army in Cachar retired to Manipur. On the role played by Gambhir Singh in Cachar, it was stated, "Gumbheer Sing ... with whom we had negotiated, raised from among his own followers a body of 500 men, who actively cooperated with our troops in expelling the Burmese from Cachar."[16] Thus, in the First AngloBurmese War, the Manipuris of Cachar tried their best to expel the Burmese from the soil of Cachar.

In the revolt of 1857, when the Chittagong mutineers marched towards Cachar, Manipuri Prince Sana Chahi Ahum alias Narendrajit Singh (a son of Raja Chourjit Singh), who was born and brought up in Cachar, revolted against the British by joining the Chittagong mutineers. On the Prince's participation, McCulloch, the Political Agent at Manipur, expressed, "Shortly after the mutineers entered Cachar, they were joined by the prince, Narendrojeet Sing, who was at large."[17] Though the mutineers wanted to enter into the territory of Manipur, Prince Sana Chahi Ahum seemed to have dissuaded them telling that it would be useless to enter into it as its Rajah Chandrakirti Singh was a dependable ally of the British Government. They, thus, decided for a great revolt against the British. The Prince made full preparation for the revolt with the sepoys coming from Chittagong. In this way, the united force fought a fierce battle at about 10 A.M. at Binnacandy (Cachar) on the 12th January, 1858. In this battle they were defeated with a loss of seventeen dead and Sana Chahi Ahum had a serious gunshot injury. The prince now fled with some Chittagong sepoys to the territory of Manipur where they were arrested by the army of Manipur. The latter sent those arrested Chittagong sepoys to the British Camp, but Sana Chahi Ahum was treated generously and brought to the capital of Manipur. After some months, the prince was sent to Cachar to face trial under the British authorities. In this regard, a report expresses:

> "Narendrojeet Sing having been tried under Act No. XIV, of 1857, and having apparently been found guilty of a criminal offence ought not to be treated as a state prisoner Honourable President in Council agrees with Lieutenant Stewart in thinking that it would be inexpedient to sentence the prisoner capitally. If imprisoned for life, it can only be the transportation beyond seas."[18]

Ultimately, Sana Chahi Ahum was transported like other rebel leaders of 1857. Besides, for the great role he played in the Revolt of 1857, this prince was recorded as a leader of 1857 revolt with a remark, "He joined the Chittagong mutineers with his followers."[19] Thus, the people of Cachar under the leadership of Prince Sana Chahi Ahum actively participated in the revolt of 1857 to restore Cachar to its people.

In 1893, there was also a case in Cachar which had created a great unrest not only in Cachar but also in Bengal. The case was popularly known as the Baladhan Murder Case. One midnight some persons entered into the bungalow of the Manager

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of the Baladhan Tea Estate, Cachar, and killed the Manager and the Chaukidar. J.B. Bhattacharjee writes, "Six Manipuris and one Gurkha were apprehended and sent to stand the trial before the Sessions Judge at Sylhet. The Judge, relying upon the purported confessions obtained under heavy torture sentenced four of the accused persons to death and the rest to transportation for life. Their case was taken up by Babu Kamini Kumar Chandra and in the High Court at Calcutta, on appeal, acquitted all the accused. The case had created a great stir all over Bengal. Maharshi Devendranath Tagore and other nationalist leaders of Calcutta helped Babu Kamini Kumar in collecting funds for the case."[20] It shows that there was a close link between the nationalist of Bengal and Cachar. Hence, the Manipuris of Cachar had their involvements time and again in the politics of India in general and Cachar in Particular.

Manipuris in the economy of Cachar

Making their settlements in Cachar, the Manipuris started economic activities like agriculture, trade and cottage industries. As already stated, Lt. Fisher wanted to enhance the revenue of Cachar by expanding the area under cultivation. But the Kuki head hunting raids on the south eastern part of Cachar disturbed the cultivators. On this matter, a report expresses, "The Kookies are commonly seen suddenly in the night, not so much with a view to plunder, as to kill the inhabitants and carry off their heads to be employed in religious ceremonies."[21] If these frontiers were to be protected, many posts of sepoys were to be established incurring heavy expenditure to the Company. The authorities of the British Government then decided to exploit the capability of the gallant Manipuris living in Cachar through an advance called *Tuccavi*.

The objective of Lt. Fisher behind this advance was "to bring under cultivation those Pergunahs which suffered in an extraordinary degree during the Burmese war, as also those lands to the Kooky frontiers."[22] He cleverly planned to give this advance to the Manipuris for cultivation on the most exposed area so that they protected the area without incurring any expenditure from the company's treasury. In 1832, Fisher wrote:

> "The sum of one thousand rupees which I wish to devote to this specific purpose, I propose to advance to Purbitta Sing Rajkoomar (the brother of Ranee Induprabha) who undertakes to establish one thousand Ryuts on the most exposed part of the frontier, and defend the neighborhood of his settlement."[23]

After three years, when the advance was very successful, Fisher again expressed, "No outrages have been committed on this part of the frontier during the last three years and several Munnipoorie chiefs and others have recently offered to take advance for the establishment of villages similar to that of Purbitta Sing."[24] Consequently, Fisher requested for more fund so that the entire Kuki frontier would be protected securely. In this regard, a report expresses, "His Honour in Council has been pleased to sanction the disbursement of a sum not exceeding 2000 Rupees in advance on loan to Munnepooree Chiefs for the purpose of enabling them to settle villages on the remaining portion of the frontier, similar to the one which has been established by Purbitti Sing."[25] Giving more advances to the other Manipuri Prince Tribhubanjit Singh, J.G. Burns reported on 20th August, 1836:

> "The Raj Koomar Triboobunjeet Sing has begged for a further advance of 600 Rs. for the purpose of settling some other villages on the southern frontier. He has had advances of Rs. 2638 and has been very successful in the objective in view, keeping the Kookies quiet, for there has not been any disturbance there for a long time."[26]

Next year, appreciating the role of Tribhubanjit Singh and Parbitta Singh on the economy of Cachar, J.G. Burns again reported on the 17th September, 1837:

> " ... Triboobunjeet Singh and Pubitter Singh, Who aided by advances from the Government have settled many families and cleared much jungle, the *Jumma* in Jaffirbund to the South West and the latter in Sonapur to the South East of this and their locations on these borders, have been of most material benefit as a protection to our more inland *Talooks* from the predatory incursions of the Kookees."[27]

Thus, the Manipuris played a leading protective role in the then society of Cachar making it economically sound.

Regarding other economic activities, there was a flourishing trade with Manipur in cloth and cattle like buffaloes, cows and ponies. R. Stewart reported on 9th July, 1857: "From Manipur about 1000 heads of buffaloes are brought over the hills every cold season together with a few cows and ponies."[28] On the prize and the use of buffaloes and ponies of Manipur, it is stated: "Manipuri buffaloes were sold in Cachar for sums varying from Rs. 80 to Rs. 120 .... The ponies of Burma and Manipur were sold at Rs. 300 sometimes.

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They were trained for race purpose in the fair held at Silchar."[29] Regarding the best cow available in Cachar and its rate, it is expressed, "The best cows in Cachar were brought from Manipur and were sold for @ Rs. 25 or 30.[30] On the annual Silchar fair (Mela), I.F. Sherer reported on the 16th July, 1860, "The last Mela was attended by a great concourse of people, and the results were so gratifying, as to encourage its continuance annually. Many buffaloes, cows, ponies and goods of all sorts, and kind were brought for sale and readily disposed.[31] In these trade activities with Manipur, some Manipuris of Cachar took a substantial role.

In cottage industries like weaving and bellmetal works, Manipuris of Cachar also played a great role. J.B. Bhattacharjee writes, "In Cachar, unlike in other parts of Bengal, the natives are agriculturists. During, "off season" only, they could indulge in other professions...The bellmetal utensils were prepared mostly by the Manipuris."[32] The historian again writes on weaving, "Only the Manipuris, Kukis, Dimachas, Mikirs and Nagas utilized their leisure hours in weaving and mostly used their cottage products .... the Manipuri *Khesh* and Kuki *pal* and the curtains knitted by the Kuki and Naga women were highly popular among all sections of the people."[33] On the same area Ranjit Kumar Dey also writes, "Once considerable quantity of cloth worked by Manipuris, Nagas and Kukis exported from Cachar."[34] Hence, the Manipuris living in Cachar also had their involvement in cottage industries up to a great extent.

Manipuris in the society of Cachar

Owing to the protection given to other communities in Cachar, the Manipuris were highly respected in Cachar. In this regard, Th. Madhai Babu narrated an event which had taken place in his village Thangjam Leikai, Sonai, Cachar, in the second half of the 19th century:

> "A granddaughter of Raja Chourjit Singh married to one Thangjam Jadu Singh of Thangjam Leikai, Sonai. This man was a Mouzadar under the British. When Jadu Singh was out of station, his wife, being honored as a Manipuri princess, used to try petty cases of the village. Once, two Muslims, who were quarrelling about their land, sought the decision of the princess. The princess heard the case and accused both the Mulims, and then forcefully ordered both the parties to be liberal minded and to take one step backward from their previous standpoints. On hearing it the parties accepted and the matter was solved."[35]

Recognizing the leading as well as protective role played by Manipuri Princes of Cachar, they were given the title 'Raja' even after the British annexation of Cachar. Besides, it is also stated that one hill in Jaribond was named Kala Pahar deriving it from the name of one Manipuri prince Kala Raja alias Dayabanta (son of Tribhubanjit Singh), who, with his uncle Sana chahi Ahum, had made the hill a hiding place during 1857 Revolt.[36] As most of the Manipuris settled in Cachar were Hindus, the region also experienced the rich culture of Manipur.

Hence, the role played by the Manipuris in the nineteenth century Cachar is really worth mentioning. They really wanted to expel both the Burmese and the British from the soil of Cachar. Their role in the cottage industry and also in the cattle trade with Manipur improved the economy of the region to a great extent. Therefore, the socio-economic and political role of the Manipuris living in Cachar is very important for the history of India in general and Cachar in particular.

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36. Oral interview with Laishram Manglemba Singha, Librarian, Cachar College, Silchar, 21 November, 2009.

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BIOEROSIONAL TRACE FOSSILS FROM THE MIOCENE SEDIMENTS OF BOKA BIL FORMATION KAIPHUNDAI, MANIPUR, NE INDIA

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Abstract

This paper documents a relatively diverse assemblage of bioerosional trace fossils macroborings from the Miocene sediments of Boka Bil Formation, exposed in and around Kaiphundai village, NH-37, Manipur, NE-India. The bioerosional trace fossils (macroborings) occurred most commonly in molluscan and associated sediments mainly in clayey shale and muddy shale. The borings represented by various ichnogenera and many ichnospecies. In the present status only three specimens have been identified, which are assigned to Gastrochaenolites ornatus; Gastrochaenolites torpedo and Caulostrepsis cretacea. Macro faunal, ichnological and sedimentological evidence suggest that the Boka Bil Formation is shallow to deep marine turbiditic sequence. Its faunas, overwhelmingly dominated by abundant and diverse molluscs, are allochthonous and comprise a mix of shallow-marine and deeper marine taxa. Only shallow-marine taxa exhibit evidence of macroborings, but even these are poorly represented, out of which only 25 samples containing borings having been recovered. The authors speculate that the rarity of macroborings reflects a combination of taphonomic processes and preserved bioerosional trace fossils indicating high-energy settings, probably in a shallow sublittoral environment.

Key words : Boka Bil Formation, Kaiphundai , Miocene, turbidites, trace fossils,

Introduction

The term bioerosion was introduced by Neumann in 1966 as an abbreviated form of the phrase biologic erosion. It has been used to identify the processes by which animals, plants and microbes penetrate into hard substrates (Bromley, 1992). The Miocene rocks

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exposed in the North Western part of the Kaphundai area , Western Manipur Hill (Figure 1) contain a rich macro invertebrate fauna dominated by bivalves, gastropods and echinoids. In addition, they display interesting traces of boring predation and many signs of post-mortem processes (bioerosion), and other taphonomical features that give important indications of the post-mortem processes acting on their shells. Bioerosion structures found on this horizon are described. The main paleoenvironmental conditions and taphonomic processes are also analyzed.

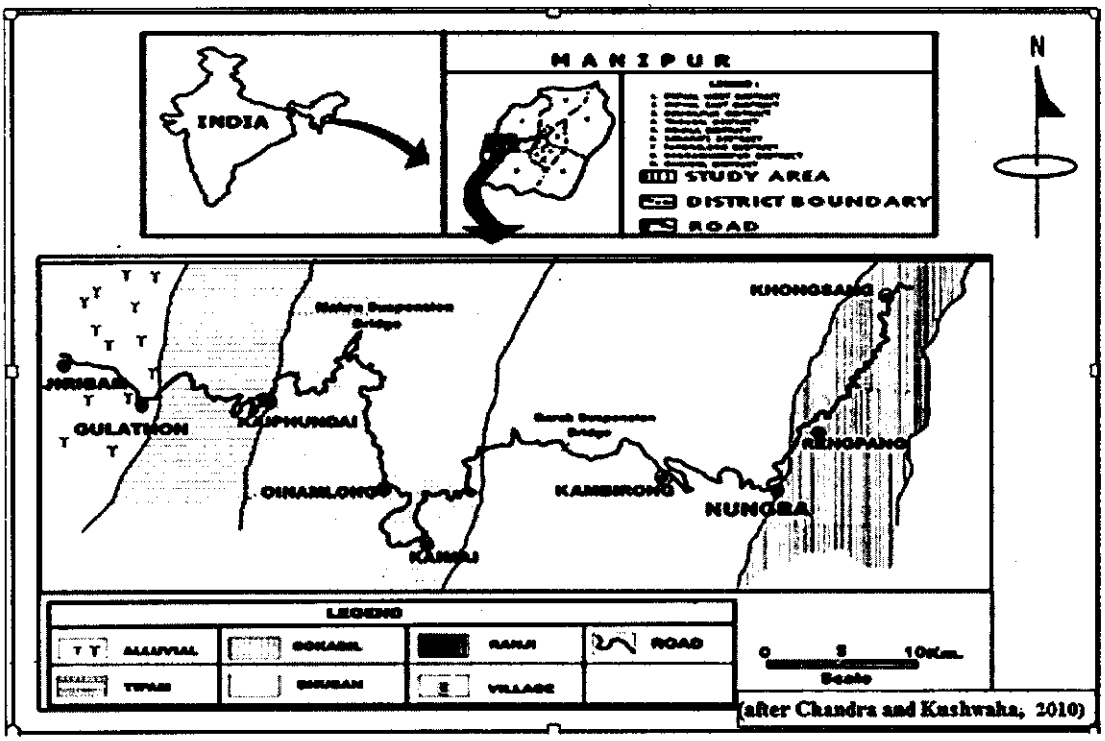

Fig.1. Location and Geological Map of the study area

The bioerosional trace fossils in the Miocene sediments in the Kaiphundai locality has been recently studied to find possible bioerosive traces in the Middle Miocene horizon which have added much new information on the spatial and temporal distribution of particular ichnotaxa, the systematic revision of taxa. However, we have still unsatisfactory database by recording and describing a relatively diverse assemblage of bioerosional ichnotaxa associated with skeletal material preserved within Miocene strata of Kaiphundai section. This assemblage comprises several macroboring ichnogenera, out

of which only three ichnogenera had been identified because of their high fragmentary and weathered nature which are collectively associated with various faunal elements, particularly molluscs.The aim of the present contribution is to describe and interpret unusual situation of the sectional horizon.

Geological Setting

Oligocene-Miocene sedimentary sequences of Manipur are represented by the Surma Group of rocks. It has been divided into two formations the lower one as Bhuban and upper as Boka Bil. The Bhuban Formation is unconformably overlain by the Renji Formation with a thin bed of conglomerate near Rengpang village. A simplified lithostratigraphic succession of the study area along with their brief description is given in *Table 1*. Lower Member of Bhuban Formation is well exposed in and around Nungba village and consists of khaki coloured shale and cross bedded, light grey sandstones. The shale facies contains bivalve fossils. Till date there is no record of trace fossil from the Lower Member of the Bhuban Formation. The Middle and Upper Member of Bhuban Formation and Boka Bil Formation represent well preserved ichnofaunal assemblages. Boka Bil Formation gradually grades upward to the Tipam sandstone near Kaiphundai village.

Table 1. Simplified lithostratigraphic succession of the study area

Group	Formation	Lithology	Age
Tipam	Tipam Sandstone	Massive sandstone, shale and mottled clay	Late Miocene
~~ Gradational contact ~~~~~			
Surma	Boka Bil	Mainly argillaceous sediments with massive-bedded sandstones, siltstone, mudstone and shale	Miocene to Late Oligocene
	Bhuban	Upper: Massive sandstone, clayey sandstone, bedded siltstone and shale Middle: Cross-bedded sandstone, massive sandstones and Clayey shale Lower: Light grey cross-bedded sandstone and fossiliferous Khaki colour shale and conglomeratic bed at the basal part with some coaly bed	
~~ Unconformity ~~~~~			
Barail	Renji	Alternations of shale and argillaceous sandstones	Oligocene

Bioerosion and Taphonomic Processes

Bioerosion is the process by which organisms sculpt or penetrate hard substrates. The resultant biogenous structures qualify as trace fossils and are named ichnotaxa (Ekdale *et al.*, 1984; Bromley, 1994). As reviewed by Pleydell and Jones (1988), such ichnotaxa are characteristic of, but not exclusively limited to, rocky shorelines, hardgrounds and reefs. Moreover, Ekdale *et al.* (1984) proposed a classification of bioerosion structures based on their morphology and ethology. This classification has been of common use among ichnologists (Martinell, 1989; Bromley, 1992) and some groups of structures have been discussed. Taylor and Wilson (2002) also proposed more informative terminology for marine organisms inhabiting hard substrates. Besides, trace fossils nomenclature is a discipline distinct from the traditional biological systematic one. This is due, in part, to the intimate relationship between trace fossils and the taphonomic processes (Macnaughton and Pickerill, 2003). Cutler and Flessa, 1995; El-Hedeny, 2005);

Bioerosion is known to be a major process driving the degradation of carbonate skelatel material and rocky siliceous and calcareous sandtone and limestones in all marine and some freshwater environments, in concert with physicochemical dissolution and mechanical abrasion. A wide range of mechanical and/or chemical boring organisms are known to infest calcareous substrates, comprising macroborers (such as sponges, bryozoans, worms, molluscs, etc.) and microborers (mainly bacteria, fungi and algae) (Golubic *et al.*, 1975; Taylor and Wilson, 2003).

In intertidal and shallow sub- littoral environments, boring marine organisms are the primary agent of shell destruction (Cutler and Flessa, 1995; El-Hedeny, 2005); their importance increases with productivity and decreases with higher sedimentation. Besides, bioerosion is an important factor making differences in the preservation of fossil fauna. Considering the fossil record, oysters constitute one of the most ubiquitous groups in marine deposits due to a high preservation potential shown by their shells. Moreover, borings appear to be widely distributed in their shells. A number of bioerosion traces refer to the activity of Clionid sponges(Bromley and D'Alessandro 1984). During the life of oysters, the influence of biological and environmental factors upon their valve morphology can be pronounced. After their death, they do not enter the fossil record without taphonomic modification on the sediment surface or within the sediment. The following paragraphs will provide some important information relating to the paleoecological influences and taphonomic processes (Kidwell, 2002).

Material and Methods

Specimens described herein are deposited in the Geological Museum of Imphal College, Manipur (GMIC). The calcareous and Muddy shale and Chalk containing the best preserved specimen were collected by the authors from the nature exposed outcrop of Kaiphundai area in the early part of September May 2016. Examination of these specimens was by hand lens and binocular microscope. Photography was with a Canon Power Shot , digital camera. The Chalk specimens were not coated for photography, but were soaked in tap water to remove salt and dried in a sunny window. The latex cast was coated with ammonium chloride for photography. Descriptive terminology of borings follows Häntzschel (1975). Our philosophy of open nomenclature follows Bengtson (1988)

Systematic Ichnology

Ichnogenus *Gastrochaenolites* Leymerie, 1842

Type ichnospecies: *Gastrochaenolites lapidicus* Kelly & Bromley, 1984, p. 797, by subsequent designation of Kelly & Bromley (1984).

Other ichnospecies: *Gastrochaenolites ampullatus* Kelly & Bromley, 1984; *Gastrochaenolites anauchen* Wilson & Palmer, 1998; *Gastrochaenolites cluniformis* Kelly & Bromley, 1984; *Gastrochaenolites cor* Bromley & D'Alessandro, 1987; *Gastrochaenolites dijugus* Kelly & Bromley, 1984; *Gastrochaenolites hospitium* Kleemann, 2009; *Gastrochaenolites oelandicus* Ekdale & Bromley, 2001; *Gastrochaenolites orbicularis* Kelly & Bromley, 1984; *Gastrochaenolites ornatus* Kelly & Bromley, 1984; *Gastrochaenolites pickerilli* Donovan, 2002; *Gastrochaenolites torpedo* Kelly & Bromley, 1984; *Gastrochaenolites turbinatus* Kelly & Bromley, 1984; *Gastrochaenolites vivus* Edinger & Risk, 1994.

Diagnosis: (After Kelly & Bromley, 1984, p. 797.) "Clavate borings in lithic substrates. The apertural region of the boring is narrower than the main chamber and may be circular, oval, or dumb-bell shaped. The aperture may be separated from the main chamber by a neck region which in some cases may be widely flared. The main chamber may vary from subspherical to elongate, having a parabolic to rounded truncated base and a circular to oval cross section, modified in some forms by a longitudinal ridge or grooves to produce an almond- or heart-shaped

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section. The general range in morphology of species of *Gastrochaenolites* is shown in [Kelly & Bromley, 1984]

Remarks: *Gastrochaenolites* isp. are typically associated with the actions of endolithic bivalves, but similar borings are also excavated by Recent coralliophilid gastropods and some sipunculan worms (Bromley, 2004, p. 462).

Gastrochaenolites Leymerie, 1842
? *Gastrochaenolites* isp.
Fig. 2 (g)

Material: One collected specimen and two additional specimens observed at the locality.

Description: Subvertical shafts slightly enlarged at their base to irregular, roughly drop-shaped chambers. Dimensions of the collected specimen: depth 28 mm, diameter at the presumed opening 13 mm, maximum diameter 15 mm. The shafts were made in the metavolcanite and filled passively with the Cretaceous sandstone to conglomerate.

Remarks: Overall shape of the trace fossils suggests their similarity to the ichnogenus Gastrochaenolites as defined, e.g., by Kelly and Bromley (1984). Gastrochaenolites usually represents dwelling chambers (borings) of molluscs; in such cases, the chambers show a precise regularity and symmetry. However, Ekdale et al. (2000) broadened the morphological range of Gastrochaenolites by including irregular, roughly drop-like trace fossils of the Ordovician age. Among the published examples of modern traces, ?Gastrochaenolites isp. resembles traces described by Fischer (1981), which were made by sea-urchins (Diadema mexicana) and decapods (Alpheus saxidomus) on basalts on the Pacific coast of Costa Rica.

Gastrochaenolites ornatus Kelly & Bromley, 1984
Fig. 2 (a-b)

Material: Two collected specimen and one additional specimens observed at the locality.

The best preserved isp., was found in three pieces; presumably it had been broken to liberate the shell of the borer, now sadly unknown. One fragment and a latex cast taken from the restored boring; two of the three sections have been glued together and the third is easily removed to demonstrate morphology. Other specimens are not well preserved; all of these specimens are preserved as longitudinal sections.

Diagnosis: (After Kelly & Bromley, 1984, p. 801)

"Gastrochaenolites that is circular in cross-section throughout. Deepest portion bears circular, sometimes serrated grooves."

Description: (Based on all specimens) Elongate, unlined clavate borings in a Chalk substrate, circular in cross section and with or without a slightly bulbous basal termination. Not infilled. Neck with a smooth shaft, gently widening towards the main chamber. The main chamber bears a sculpture of prominent, parallel circular, short and oblique striations. The most completed specimen is 53 mm long, albeit incomplete, and about 15 mm in maximum diameter.

Remarks: All of the identifiable Gastrochaenolites borings that I have collected from the kaiphundai outcrop expoded near the NH-37, Manipur, had been assigned to G. ornatus; many other specimens are too poorly preserved to enable a more complete designation than Gastrochaenolites isp.

Gastrochaenolites torpedo Kelly and Bromley, 1984
Fig. 2 (c-e)

Description.— elongate specimen, 22 mm in length and maximum diameter (approximately centrally located with respect to its long axis) of 86 mm. Base acutely parabolic, neck region unobserved. Sample preserves its producing, but indeterminate, gastrochaenid, lithophagid or mytilid bivalve.

Remarks Gastrochaenolites torpedo is restricted to shallow, euphotic zone. Lithophaga lithophaga, producer of this boring in the Mediterranean Neogene is abundant to the depth of lm, and less common up to 10 m depth . Distribution of some borings depends on inclination of the substrate. Occurrence of G. torpedo on steep surfaces is consistent with observations by Bromley & D'Alessandro (1987) from Plio- Pleistocene coast of Southern Italy and latter by Gibert et al. (1998) from Pliocene rocky coasts of the western Mediterranean basin. Gastrochaena dubia, main producer of G. lapidicus in the Mediterranean Sea shows wider bathymetric range than L. lithophaga and greater tolerance to sediment particles suspended in the water and settled on the substrate (Bromley & Asgaard, 1993a). It is found on inclined and locally horizontal surfaces, with extremely low accumulation rate. The described assemblage of borings is composed of overprinting of a few boring

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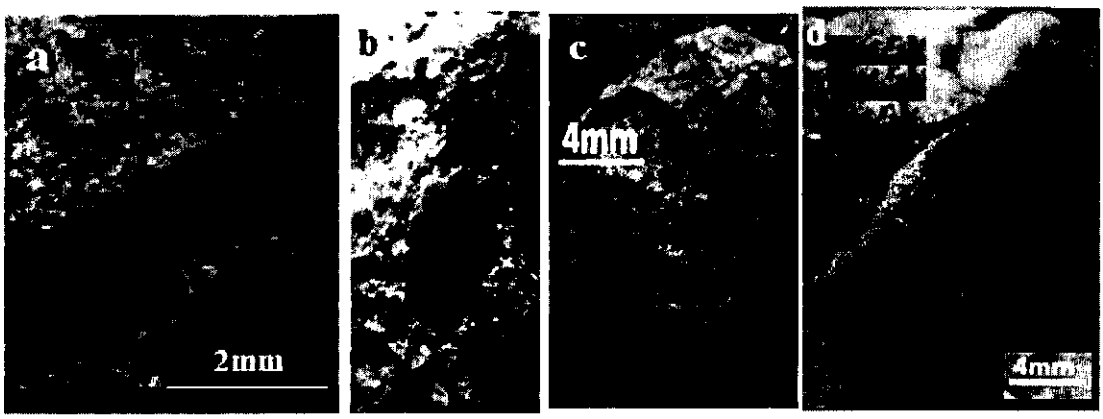
communities. Surfaces colonised by polychaetes producing Caulostrepsis have been afterward colonised by bivalves producing Gastrochaenolites. Due to deepening caused by the Miocene transgression, at a depth up to 20 m (upper photic zone) sea floor was progressively colonised by sponges of the genus Cliona. Commonly, they abraded bivalve borings of the ichnogenus Gastrochaenolites, which were formed earlier in shallower waters. Then, within mostly dim environment, larger sponges produced Entobia cf. solaris, which cross cuts the smaller entobian borings. . The boring assemblage does not represent one community, but several communities overprinted during migration of shoreline and increasing water depth. In general, they indicate a change from very shallow turbulent, well-oxygenated waters, dominated by boring polychaetes and bivalves, to deeper lower-energy waters dominated by boring sponges at a depth of several or even a few tens of meters. Such phenomenon was caused by the major regional transgression (Bassant, 1999), which can be attributed to the higher order eustatic fluctuations

Ichnogenus Caulostrepsis Clarke, 1908
Caulostrepsis cretacea Voight, 1971
Fig. 2 (f)



Description : Smooth, curved to sigmoidal, horizontal, elongate galleries with fused limbs and no central vane, but with welldeveloped central axial depression. Incomplete length up to 86 mm, overall width (flattened) 0.2 mm throughout. U-bend terminations and apertural openings not observed.

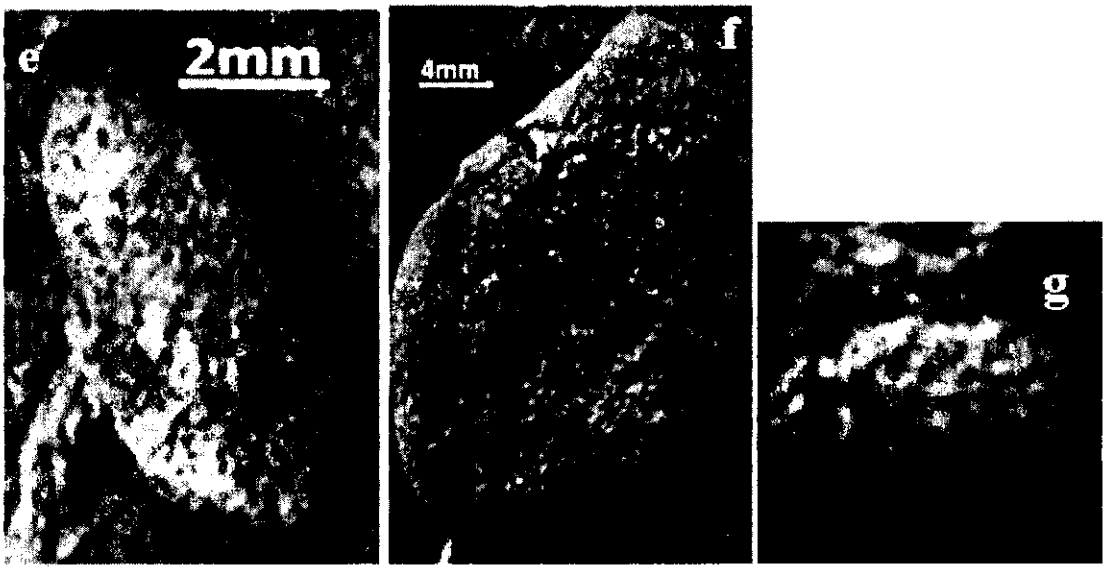


Fig. 2 : ***(a-b)Gastrochaenolites ornatus*** **Kelly & Bromley, 1984;** ***(c-e) Gastrochaenolites torpedo*** **Kelly and Bromley, 1984 ;** ***(f) Caulostrepsis cretacea*** **Voight, 1971;** ***(g) Gastrochaenolites*** **isp.**

Discussion and Conclusions

The stratigraphic sequence of Boka Bil exposed in the region shows tectonic deformations of turbiditic sediment having a long interval of weathering, which is dominated by diverse and abundant molluscs. As a result, some surfaces were firm while others retained the character of a hard rock. The transgression at the region probably began with a non-sedimentation episode characterized by the appearance of the described burrowing/boring traces. We may presume high-energy settings, probably in a shallow sub-littoral zone. The distribution and succession of the borings can reflect bathymetric trends, and hence could be crucial in recognition o f relative sea level changes. Therefore, borings may be applied as a useful accessory tool in sequence stratigraphy, especially in transgressive rocky coast settings.

The molluscan taxa, particularly those originally preferentially inhabiting shallow-water regimes, possess macroborings in the form of numerous *Gastrochaenolites*. The rarity of macroborings in Boka Bil Formation is enigmatic given the numerous and diverse macrofaunas present in the sequence. We suspect that their rarity reflects a complex

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and possibly variable taphonomic history prior to final burial. Regrettably, because the macrofaunas are to varying degrees clearly allochthonous, it is difficult to assess confidently the biostratinomic processes to which they were subjected. However, we have indicated that many of the more typically shallow-water taxa in which the macroborings are present were obviously subject to extensive reworking and fragmentation, presumably by high energy wave action, currents, tides or waves demonstrated that under such conditions shells with bioerosional structures are preferentially subject to fragmentation and destruction by mechanical reworking.

Traces of decapods described by Fischer (1981) from modern basalt coast of Costa Rica are similar to the traces described as? Gastrochaenolites isp. We may presume that ?*Gastrochaenolites* isp. of the sectional area represents bioerosive traces of decapods: they are less regular compared with *Gastrochaenolites* produced by boring bivalves. We may even suggest that *Gastrochaenolites* isp., of the sectional area were produced by the same decapods trace maker: this possibility is supported by a similar diameter of both traces and more significantly . Besides the substrate control, patchiness of the ichnological record could be influenced by some other factors, e.g., by exposure to wave action and currents. However, we find the following scenario for the development of the fossil record at the locality the most probable:

1) Pre-Miocene tectonic deformations and a long interval of Pre- Miocene weathering. As a result, some surfaces were firm while others retained the character of a hard rock.

2) The transgression of Kaiphundai section were probably began with a non-sedimentation episode characterized by the appearance of the described burrowing/boring traces. We may presume high-energy settings, probably in a shallow sublittoral zone.

Present surfaces of natural and artificial outcrops or in soil skeleton retain in places a character of solid rock, but in other places they weather into a semi-consolidated substrate. As we recognized "soft" weathering and the patches of hard, less weathered rock, we presume that a variation in degree of tectonic stress is responsible for the differences in weathering style.

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A STUDY OF EFFECTIVE UTILIZATION OF SELF-LEARNING MATERIALS THROUGH DISTANCE EDUCATION PROGRAMME.

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Abstract

Distance Education is the need of the present time so as to achieve the objectives of Sarva Shiksha Abhiyan (SSA). Effectiveness of Distance Education programme depend on the optimum utilization of a variety of communication services to bring desirable outcomes. Hence various training materials were developed. Realizing a need of utilization of such resource materials, a programme for training of master trainers, utilizing different resources and training materials was organized.

Keywords : Distance Education Programme (DEP), Sarva Shiksha Abhiyan (SSA), desirable outcomes, resource material, master trainers.

Introduction

Sarva Shiksa Abhiyan is designed to achieve the goals of universalization of Elementary Education. It has been a -tio-l endeavour for which both the Central Government have been devising various measures through different modes. Distance education is the need of the present time so as to achieve the objectives of SSA. Effectiveness of Distance Education programme depend on the optimum utilization of a variety of communication services to bring a desirable outcome. To reach a large target group of SSA functionaries, it is considered to be an important strategy so as to suit all level/category of functionaries.

DEP-SSA has undertaken various activities like identification of the training needs, planning of need-based activities for the State, capacity building programmes for the teachers and other SSA functio-ries, and capacity building activities in the development of distance delivery modes, etc in the states. Various training materials were developed by SSA Manipur in collaboration with DEP-SSA. devolopment of material and its dissemination is not sufficient for the achievement of the -tio-l objectives, rather

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its effectiveness depend on utilization of the training materials. Realizing the need of utilization of such resourcre material, a programme for the training of Master Trainers on utilization of different types of resource and training materials was organized by DEP-SSA for the state of Manipur.

The main purpose of the training programmes was to:

- Acquaint the master trainers on various types of self-learning materials-viz., Print, Audio, Video and Tele-conferencing.
- Acquaint the master trainers towards effective utilization of the Print, Audio, Video, and Tele-conferencing materials.
- Familiarize the master trainers about the various methods for effective use of resource materials.

Objectives :

i) To know the effective organization of the training programme for the master trainers.

ii) To know the quality of support materials provided for the training programme.

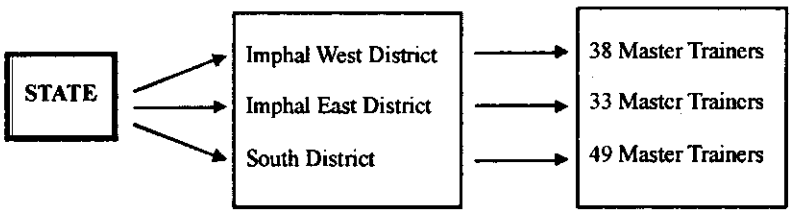
iii) To know the impression of the participants towards different components (Media Technology, through distance learning, group discussion, activities, etc.) Used/Covers during the training programme.

Method

Survey method was adopted to examine the utility and effectiveness of the training programmes organized for the master trainers of the 3 (Three) Districts in Manipur State viz., Imphal West District and South District, Manipur.

Sample

The sample of the study consists of 120 master trainers. The details of the sample is given below:



Methodology:-

DEP-SSA developed a structured opinion/feedbacks format to know the utility and effectiveness of the training programme. The format contains 16 items covering different aspects like organization of the training programme, general impression of the participants towards the training programme, Strengths of the training programme, weak points of the training programme and suggestions for further developments etc.

Analysis and interpretation:

Analysis and interpretation of data was made in the light of objectives and hypothesis of the study.

Table -1.1

Opinion of the participants towards the support material :

SL NO.	ITEM	RESPONSE	MANIPUR		South District Manipur N=49
			Imphal West Dist.N=38	Imphal East Dist.N=33	
1.	Objectives of the programme were communicated to the participants beforehand.	YES	63.16	78.79	77.55
		NO	36.84	21.21	22.44
2.	Support materials about the programme were provided in advance.	YES	71.05	63.63	34.69
		NO	23.68	36.36	63.26

The table 1.1 shows the real status of the pre-arrangement of the training programme. Though most of the participants of Imphal West, Imphal East Districts and South District Manipur viewed that "objectives" of the training programme were communicated to them beforehand but about 29.01% of participants in Imphal West and East Districts and 22.44% in South District Manipur are not in favour of the above statement. Similarly, 67.34% of participants in Imphal West and East Districts and 34.69% in South District Manipur have viewed that the support materials about the programme was provided to them in advance but at the same time 63.26% of the participants of the

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South District Manipur do not agree with the above statement that they received any support material in advance. So with regard to objectives of the training programme hypothesis(1,2,3) is accepted whereas with regard to the support material, the hypothesis is accepted by Imphal West District and East but rejected by South District Manipur, that is about 63.26% of participants had not received the material in advance.

Table -1.2

Opinion of master trainers towards quality of support material:

SL No.	Items	Response	Manipur		South
			Imphal West Dist. N=38	Imphal East District N=33	District Manipur. N=49
1.	Quality of support material	Excellent	15.38	18.18	4.08
		Good	81.57	75.75	69.36
		Poor	2.65	6.07	-

The above table clearly shows about the excellency of the support materials. About 70% participants viewed that quality of the support of materials was good and satisfactory. On the other hand, only 5 to 20 % of the participants viewed it as excellent. This shows that though the quality of support material is good which helps the participants during training programme but further improvement is essential, so the hypothesis(1,2,3) is partly accepted and partly rejected.

Table – 1.3

General opinion of participants through distance learning material (to SLM):

SL.NO	ITEM	RESPONSE	MANIPUR		South District Manipur N=49
			Imphal west district, N=38	Imphal East District, N=33	
1.	Opinion about self material	Very useful	42.10	54.54	12.24
		Useful	52.63	39.39	40.81
		Not useful	-	-	-

In table 1.3 clearly shows that about 48.32% of the participants of Imphal West and East Districts reported that the self learning materials were very useful for the teachers as well as master trainers whereas only 12.24% participants of the South District Manipur reported the same. So, there is a difference of opinion of the participants, as far as usefulness of SLM is concerned. With regard to SLM, the hypothesis (1,2,3) is partly accepted for the Imphal West and East Districts and rejected for the South District Manipur.

Table- 1.4

Opinion of the participants towards the use of Audio and Video materials:

SL.NO	ITEM	RESPONSE	MANIPUR		South District Manipur
			Imphal West District, N=38	Imphal East District, N=33	
1.	Audio Cassettes	Very useful	13.15	15.15	12.24
		Useful	34.21	27.27	22.24
		Not useful	-	-	08.16
2.	Video Cassettes	Very useful	05.63	03.03	18.36
		Useful	21.05	06.06	26.73
		Not useful	02.63	03.03	02.04
3.	Audio Broadcast	Very useful	10.52	15.15	04.08
		Useful	31.15	21.21	22.44
		Not useful	02.63	-	06.12
4.	Video Broadcast	Very useful	-	-	12.24
		Useful	21.05	03.03	22.44
		Not useful	02.63	-	04.08

The above table indicates the usefulness of the various modes of media in teaching learning process. It is clearly observed that very few participants (even less than 40%) from the 3(three) districts viewed that audio and video cassettes are useful for the training programme. Again there is a big question with regard to the use of various modes of Distance Learning Material. It poses a challenge to the effectiveness of distance learning material. So, the hypothesis (1,2,3) is rejected with regard to the use of audio, video programmes.

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Table – 1.5

Responses of the participants towards the use of Teleconference, Website, Multimedia:

SL.NO	ITEM	RESPONSE	MANIPUR		South
			Imphal West District, N=38	Imphal East District, N=33	District Manipur, N=49
1.	Teleconference	Very useful	13.15	03.03	02.04
		Useful	15.78	15.15	10.20
		Not useful	-	-	08.16
2.	Website	Very useful	02.63	-	06.12
		Useful	13.15	09.09	14.28
		Not useful	02.63	03.03	08.16
3.	Multi media	Very useful	13.15	06.06	20.40
		useful	15.78	-	42.85
		Not useful	-	03.03	02.04

The above table shows the response of the participants of Imphal West and East Districts towards the use of teleconference, website and multimedia. It is found that maximum number of participants are not attending the above programmes. Only 15.78% of participants of Imphal West District, 15.15% of Imphal East District, and 10.20% 0f South District Manipur viewed that the programme of teleconferencing is useful. Similar is the status with regard to usefulness of website and multimedia packages. So, the hypothesis (1, 2, 3) is rejected.

TABLE – 1.6

Opinion of the participants of Imphal (West & East Districts)

SL.NO.	ITEM	RESPONSE	MANIPUR		South
			Imphal West District, N=38	Imphal East District, N=33	District Manipur, N=49
1.	Group Discussion	Very useful	34.21	18.18	02.04
		Useful	34.21	21.21	22.44
		Not useful	-	-	08.16
2.	Activities/Demonstrations	Very useful	47.36	27.27	12.24
		Useful	34.21	21.21	22.44
		Not useful	-	-	08.16

The Table 1.6 reveals the option of the participants of Imphal West and East Districts, Manipur regarding the methods used in the training programme. About 34.21% participants of Imphal West District reported that the method used was very useful with regard to group discussion whereas 21.21% and 24.44% participants of Imphal East and South District Manipur respectively reported that it is useful. Similarly, 61.22% participants of South District Manipur and 37.06% of Imphal West and East Districts reported that activity and demonstration method is very useful.

Table - 1.7

Responses of the participants towards the programme co-ordinators and Resource persons :

SL.NO.	ITEM	RESPONSE	MANIPUR		South District Manipur N=49
			Imphal West Dist. N=38	Imphal East Dist. N=33	
1.	Facilitator/programme co-ordinators.	Very useful	50.00	48.48	30.61
		Useful	36.84	24.24	53.06
		Not useful	-	-	-
		Very useful	60.52	60.60	30.61
2.	Resourse persons	Useful	31.57	36.36	63.26
		Not useful	-	-	-

Above table shows that 50% participants of Imphal West District, 48.48%, Imphal East District reported that services of facilitators and programme cordinators were very useful; whereas 30.61% participants of South District Manipur reported the same in both the Districts, the response was less than 50% and again there is a difference with regard to the opinion of the two districts. Similarly, more than 60% of the participants of Manipur (Imphal West and East Districts) reported that the Resource Persons of the training programme were very efficient and effective. But only 30.61% participants of South District Manipur reported the same.

Educational Implications

At the end of the training programme all the participants were asked to express their opinions i.e., to suggest some measures so as to improve the quality of such training in future. The suggestions obtained from participants, organizers and the investigators for improving the quality of such training programme in future are as follows:

- Duration of the training programme should be increased to 4/5 days so as to cover the details of the utility of distance learning material and its effectiveness
- Practical experience should be provided to the participants about its use as training material
- Discussion should be constituted as an integral part of whole training programme. Provision of group discussion should be made for effective and given priority. Participants should be encouraged to take active communication part in discussion.
- Teleconferencing programme should be made on effective utilization of distance learning material.
- Resource material regarding the training programme should reach to all the participants well in advance and accountability must be fixed on it.
- SLM for high School Teachers may be developed.
- Provision should be made in school time-table to use audio-video material in the class-room.
- Same type of training programme should be conducted in all districts and problems related to field area should be discussed.

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CHANGES OF PHENOLIC COMPOUNDS IN THE HOST PATHOGEN INERACTION

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Abstract

During the investigation *Gravillea robusta* wood infected by *Schizahyllum commune* along with uninfected wood were analysed. Maximum amounts of total phelols and *ortho - dihydric* phenols were recorded significantly decreased during the pathogenesis as compared to the healthy wood Fungal fructification shows less amount of phenol content.

Key words : *Greevillea robusta, Schizohyllum commune,* total phenols, *ortho-dihydric* phenols, fungal fructification.

Introduction

Resistance of plants to parasites is determined by their ability to inhibit the invader either during penetration of the host or during their development in the tissues. Various works on the accumalation of phenolic compounds and their oxidation products (quinones) in plants in response to infection and injury has been reported by Rohringer and Samborski (1967). Kue' (1992), Cruickshank and Perrin (1964). The literature on the role of phenolic compounds in pathogenesis has also been reviewed (Kosuge, 1969; Singh and Chand, 1971 ; Frield, 1979 and Scholosser, 1980). The inactivation of extracellular microbial enzymes by the phenols or quinones present in plants after penetration iscertainly a defensive mechanism. The concentration of phenolic compounds also very with the age of the tissues (joshi and Purkash, 1981). the changes in total phenols have also been worked (Nema, 1079 ; Reddy and Rao, 1979). Ortho-dihydric phenols are important in disease resistance reactions and can be easily oxidized by phenoloxidases. The significance of phenolic compounds in the host parasite interaction is complex and needs more investigation. Hence, studies on the changes of total phenols and ortho-dihydric phenols in the host tissues of *Grevillea robusta* infected by *Schizohyllum commune* have been made.

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Materials and Methods

1g powdered samples of dead healthy wood, infected wood and fungal fructification were boiled for 10 minutes with 15 ml. of 80% ethanol. After cooling, the extract was throughly grinded for 5 minutes in a mortar with pestle and filtered through a Whatman No. 41 filter paper. The alcohol extract was directly used for the analysis of total phenols and ortho-dihydric phenols.

Total Phenols

Estimation of total phenols was done by the method of Bray and Thorpe (1954). 1 ml. of Folin-Ciocalteu reagent was added to 1 ml of the above extract followed by 2 ml of saturated sodium-carbonate solution (20%). After shaking, it was placed in a boiling water bath for 1 minute and the volume was made upto 5 ml with distilled water. Then the coloured intensity was measured at 650 nm. A reagent blank with distilled water was also used during the estimation The amount of phenol content in the plant extract was calculated from the standard curve of catethol.

Ortho-dihydric phenols

Ortho-dihydric phenols was determined according to Arnow (1917) Alcohol extract of about 1 ml was reacted with 0.05N HCL followed by 1 ml of Arnow 's reagent and 2 ml of IN NaOH solution. Then the volume was made up with distilled water and the pink colour was measured in a Klett – Summerson Colorimeter at 515 nm. Cathecol is used as a standard and the amounts were calculated.

Results

The results in the Table 1 show the triplicate mean value for every observations. In the dead healthy tissues the amount of total phenols (297.32 mg/100g) was found higher than that of the infected tissues (99.50 mg/100g). Similarly the maximum amounts of ortho-dihydric phenols present int he dead healthy wood was also found to be very significantly decreased during the pathogenesis.

Table 1 : Changes in total and ortho-dihydric phenols in the *Grevillea robusta* wood during *Shizophyllum commune* infection.

Samples	Total Phenols (mg/100g)	Ortho-dihydric phonols (mg/100g)
Dead healthy wood	297.32	267.00
Infected host	90.56	28.05
Fungal fructification	90.30	10.50

The finding of Ortho-dihydric phonols in dead healthy tissues, infected tissues and *Schizophyllum* function were 275 mg/100g. 28.05 mg/100g and 10.50 mg/100g respectively. As in the case of Ortho-dihydric phonols the value of total phenols in the fungal fructification was found less than the host tissues.

Table 2 : Total nitrogen, protein and total amino acids content of healthy and infected wood of *Grevillea robusta*

Samples	**Total Nitrogen % g**	**Total Protein % g**	**Total Amino acids % g**
Dead healthy wood	0.2999	1.6800	0.0360
Infected host	0.4999	1.8700	0.2030

Discussions & Conclusions

Leatham et al. 1980) observed that the oxmdized products of phenolics may also participate in the regulation of fungal metabolism. The diverse biological activities of certain oxidised phenolics, such as puinones and free radicals, have the ability to inactivate certain biologically important substances such as proteins, enzymes, and nucleic acids (*Kosuge,* 1969, *Peirpoint,* 1970; *Leatham etal.,* 1980). The findings in te *increased* rate of total introgen, protein and amino acids content in the infected host tissues might also be correlated with the phenotic substances (Tab.e 2). Hare (1966) points out that aromatic amino acids such as poly-phenols, phenolic glucosides, flavonoids, *anthocyanins* and coumarin derivatives tend to accumulate in and around infected plant tissues, and also in tissues adjacent to wounds presumably they might exert a fungitoxic effect.

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From the present investigation it might be suggested that the reduction in the amount of the total and ortho-dihydric phonols in the host infected wood during the *Schizophyllum* infection is generally due to the oxidation of these phenols with the activities of phenolic engymes into various derivatives that may be readily utilized during the fungal metabolism. The minimum quantity of these compounds as found detected in the fungal fruictifucation might be explained because of the fact that the fungus does not need these compounds for its metabolic activities except for defensive mechanism.

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FIRST RECORD OF THE OCCURRENCE OF OLIGOCENE ICHNOFOSSILS IN THE LAIMATON HILL, THANGJING RANGE, MANIPUR INDO MYANMAR REGION

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Abstract

The occurrence of ichnofossils of *Skolithos* ichnofacies are recorded for the first time from the Oligocene flysch sediments of Laisong Formation, exposed in the Laimatol hill of Thangjing Range, Manipur. A detailed ichnological study of the recorded ichnofossils has been performed for the depositional environment aspects of the particular stratigraphic sequence. Those ichnofossils are associated with massive sandstone, thinly laminated shale and lenticular siltstone facies. Total **5** ichnospecies of 3 ichnogenera have been identified which include, *Ophiomorpha nodusa, Skolithos linearis, S.verticalis, Thalassinoides horizontalis* and *Th. paradoxicus of Skolithos* ichnofacies. Ethologically these ichnogenera produced by dwelling and feeding activities of the infaunal organisms, in shallow marine environment. The presence of *Skolithos* ichnofacies indicates sandy shale substrate and high energy conditions, shallow marine environment during the deposition of the Laisong sediments.

Keywords: Ichnofossil, Oligocene, Laisong, Laimaton, Thangjing, Manipur

1. Introduction

In recent years, the ichnological studies have been carried out in many parts of India. These studies are mainly concerned with the contributions of Badve and Ghare (1978,1980), Biswas (1981), Borkar and Kulkarni (1992, 2006), Chiplonkar and Badve (1970), Desai and Patel 2008, Guha *et al.*(1994), Howard and Singh (1985), Kulkarni (1986), Kulkarni and Ghare (1989, 1991); Kumar et al. (1975,1982), Kundal

and Dharashivkar (2006); Kundal and Mude (2008), Patel and Shringarpure (1990, 1992); Sudan *et al* (2002,), Srivastava and Kumar (1992), Sanganwar and Kundal.(1997) , Sanganwar (1998, 2000), Sudan, et al (2002) Tondon and Bhatia (1978) in the western region of India and Bandopadhyay *et al.* (2009); Chandra and Kushwaha. (2008); Chandra *et al* (2010); Hemanta *et al.* (2008), Reddy *et al* (1992) and Tiwari *et al,* (2011) in the north-eastern region. However rich and diverse ichnofossil assemblage of the Laisong sediments of Laimaton hill, Thangjing Range is not yet explored by any of the previous workers. This paper is an attempt to record and describe the assemblages of ichnofossils from the Laisong Formation of Laimaton ,Thangjing Range Manipur for the reconstruction of the depositional environment of Laisong sediments.

2. Locality descriptions

Assemblage of ichnofossils described in this paper has been collected from two localities of the Laimaton hill, Thangjing Range Manipur. It is an integral part of the Indo- Myanmar Range. The first locality (24°37'0.2" N Latitudes & 93°41'32.9" E Longitude) is in the southern part of Laimaton. In this location ichnofossils are associated with sandy shale, siltstone and bedded sandstone facies. The ichnospecies collected from this locality are *Thalassinoides* and *Skolithos verticalist.* The second locality (24°36'54" N Latitudes & 93°41'44.9" E Longitude) is in the western part of Laimaton. From this locality *Ophiomorpha, Skolithos* and *Thalassinoides* are collected which are associated with Trough cross-bedded and massive sandstone facies sandstone and sandy sandstone facies.

3. Systematic Ichnology

For the identification and classification of the present ichnofossils, Treatise on Invertebrate Paleontology Haentzschel (1962, 1975); and classification scheme suggested by Simpson (1975), Seilacher (1964, 1967) has been followed and using the binomial system of nomenclature and described alphabetically. Altogether 7 ichnospecies have been identified from 3 ichnogenera such as *siliquaria, Ophiomorpha nodosa, Palaeophycus alternatus, Palaeophycus tubularis, Planolites beverleyensis, Phycodes* isp, *Psilonichnus upsilon, Rutichnus irregularis and Thalassinoides* isp (Pl. 1, 2, 3). Their systematic descriptions are given below.

Ichnogenus: *Ophiomorpha* Lundgren (1891)
Ichnospecies: *Ophiomorpha nodosa* Lundgren, 1891
(Fig.1a)

Material : Sp. No. DGIC /IF/S-131

Description : The burrow is vertical shaft, unbranched tunnels, consisting of regular distributed discoid pellets, and preserved as full relief. Diameter of burrows varies from 6-8 mm and pellets diameter ranging from 2 to 3 mm and observed length is about 2 cm. The tunnels are filled with same sediments of the host rock.

Remarks : The main morphological features of the recorded burrow is very identical with the

Ophiomorpha nodosa Lundgren (1891) reported by Patel et al. (2008) from Jurassic of Kachchh, Gujarat; Kundal and Dharashivkar (2006) from the Gaj Formation.

Occurrence : Massive sandstone facies of the Lower Barail (Laisong) Formation, exposed near Laimaton Hill, Thangjing Range, Manipur

Ichnogenus: *Thalassinoides* Ehrenberg (1944)
Ichnospecies: *Thalassinoides horizontalis* Myrow (1995)
(Fig.1b)

Material : Sp. No. DGIC /IF/S-131

Description : Smooth, unlined, three dimensional, horizontal burrow system showing Y/T shaped branching. The diagnostic features of this ichnospecies include bedding parallel oriented network, absence of vertical oriented offshoots from polygon framework and constant diameter of the individual tunnels. Tunnels are straight to curved; length varies from 100 to 250 mm and diameter varies from 42 to 60 mm. Burrows chiefly consist of horizontal tunnels that bifurcate at an angle of 80°–170°. Some of the burrow walls show scratch marks.

Remarks : The specimens differ from the type material of Myrow (1995) only in diameter. *T. horizontalis* resembles *T. bacae* but differs from it in lacking entirely of vertical shafts. *T. Horizontalis* is robust and often occurs on the ripple marked silty-sandstone. Although the diameter of the burrow as suggested by Myrow (1995) is one of the prime factors in distinguishing the ichnospecies but in the present case overall morphological features are identical to ichnospecies *T. horizontalis*.

Occurrence : Massive sandstone facies of the Lower Barail (Laisong) Formation, exposed near Laimaton Hill, Thangjing Range, Manipur

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Ichnospecies: *Th. paradoxicus* Rieth (1932)
(Fig.1c)

Material : Sp. No. DGIC /IF/S-131

Description : Endichnial, full relief, horizontal to slightly oblique, three-dimensional irregular burrow system spread on the bedding plane. The burrow system comprises of vertical to inclined shaft connected to surface; bifurcations are commonly T-shaped and also show swelling at junction. Length of branch varies from 300 to 500 cm and diameter from 15 to 30 mm. The burrows fill is different from the surrounding.

Remarks : *T. paradoxicus* is different from the *T. horizontalis* consisting of vertical shaft and branch dichotomous (Howard and Frey 1984). *Thalassinoides* is a facies-crossing form most typical of shallow-marine environment and is produced mainly by crustaceans (Frey *et al* 1984).

Occurrence : Argilaceous sandy sandstone facies of the Lower Barail (Laisong) Formation, exposed near Laimaton Hill, Thangjing Range, Manipur

Ichnospecies: *Thalassinoides* isp.
(Fig.1d)

Material : Holotype. No DGIC/IF/S-157 -158

Description : Cylindrical to sub cylindrical, Y-shaped, horizontal branching tunnels of widening 2 to 4 cm and observed length about 12 cm; surface ornamented with scratch mark, different in colour from the host rock, swelling at the bifurcation points, preserved as full relief and disposed parallel to slightly oblique to the bedding plane.

Remarks : On the basis of the presence of cylindrical Y shaped, horizontal branching tunnels and swelling at the bifurcation points present burrow is quite identical with *Thalassinoides paradoxicus* Woodward, (Kundal and Dharashivkar 2006). However, the present ichnospecies is partially preserved and therefore it is described as *Thalassinoides* isp till better material available.

Occurrence : Argilaceous sandy sandstone facies of the Lower Barail (Laisong) Formation, exposed near Laimaton Hill, Thangjing Range, Manipur

Ichnogenus: *Skolithos* Haldemann (1840)
Ichnogenus: *Skolithos linearis* Haldemann (1840)
(Fig 1e)

Material : Holotype. No DGIC/IF/S-157 -158

Description : Vertical or steeply inclined, unbranched, cylindrical or subcylindrical, lined or unlined burrow perpendicular to the bedding plane with a structureless fill. It occurs as closely spaced or isolated tubes on bedding planes. The depths of burrows vary in different burrow populations and maximum depth (Plate 3g) observed is 35 mm with diameter of 10 to 12 mm. It is also appearing as circular to subcircular outlines (Plate h and i) on bedding plane and standout as high relief burrow, infill material is different from the surrounding matrix and mostly seen as light colour.

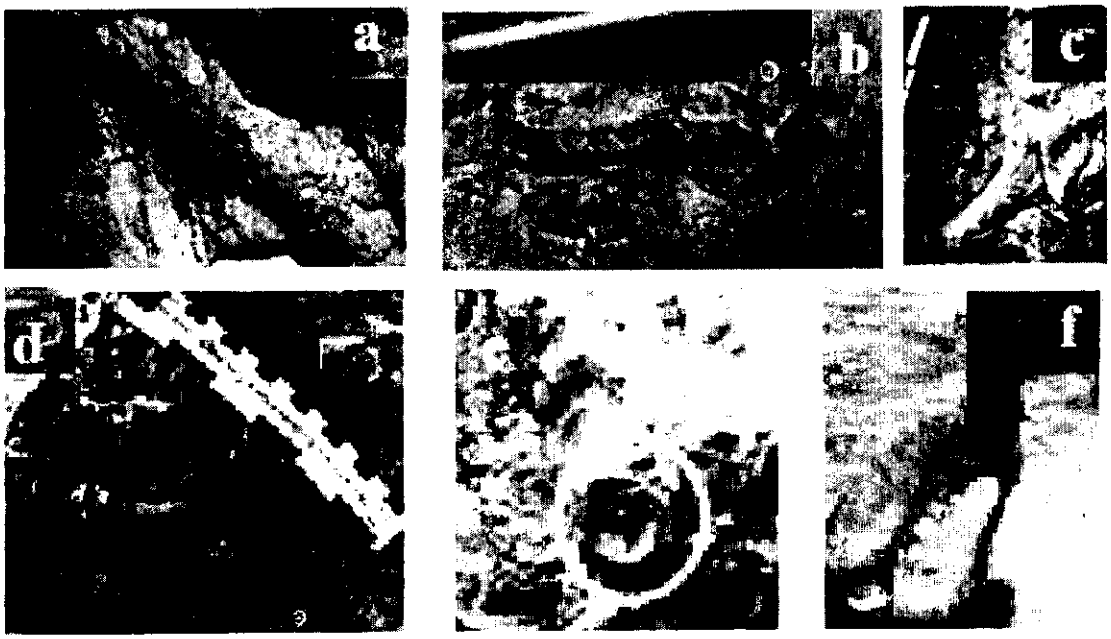

Fig.1. (a) *Ophiomorpha nodosa*, specimen no. DGIC/IF/S-205. (b) *Thalassinoides horizontalis*, specimen no. DGIC/IF/S-206. (c) *Th. paradoxicus*, specimen no. DGIC/IF/S-207. (d) *Thalassinoides* isp, specimen no. DGIC/IF/S -208. (e) *Skolithos linearis* specimen no. DGIC/IF/S-210. (f) *S. verticalis*., specimen no. DGIC/IF/S -210

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Remarks : Morphologically, this specimen clearly falls within the range of *Skolithos linearis* as described by Haldemann (1840)

Occurrence : Argilaceous sandy sandstone facies of the Lower Barail (Laisong) Formation, exposed near Laimaton Hill, Thangjing Range, Manipur

Ichnogenus: *S. verticalis* Hall. (1847)
(Fig 1f)

Material : Holotype. No DGIC/IF/S-157 -

Description : Present burrows are cylindrical, unbranched straight tubes parallel to each other, more or less uniform diameter, disposed vertical to bedding plane and preserved as full relief. The diameter of burrows varies from 8-10 mm different burrow populations and maximum depth (Plate 3g) observed is 35 mm with diameter of 10 to 12 mm.

Remarks : On the basis of presence of vertical, unbranched, cylindrical tube ,the present specimens are approaching to *Skolithos verticalis* Hall (1843), reported by Patel et al. (2008) from the Middle Jurassic of Kachchh.

Occurrence : Argilaceous sandy sandstone facies of the Lower Barail (Laisong) Formation, exposed near Laimaton Hill, Thangjing Range, Manipur.

4. Environmental significance

Rocks of the Laisong Formation, exposed in the Laimatol Hill of Thangjing Range, Manipur are studied at two different localities, for their trace fossils content. The section at the First locality shows intercalated sequence of shale and sandstone, the proportion of the arenaceous sediments increases in the upward direction while thesecond section comprises of mainly arenaceous sediments, is highly bioturbated and consists of ethologically diverse group of trace fossils. These largely constitute domichnia and fodinichnia associations and show existence of close affinity. Domichnia are the cylindrical dwelling burrows having strong wall lining of suspension feeders (Simpson 1975). The domichnia signatures are tangibly manifested from the recorded forms like *Arenicolites* isp., *Ophiomorpha borneensis*, and *Skolithos linearis* in sandstone of the second n locality.,

Thalassinoides horizontalis and *Th. paradoxicus.*These trace fossils are found in silty-sandstone and silty-shale exposed at Laimaton locality. The clastic sediments are characterized by the vertical 'U' 'I' and 'Y' shaped lined burrows like, *Ophiomorpha*, and *Skolithos.* Y-shaped *Polykladichnus*, and *Skolithos* are also dwelling burrows of suspension feeding organisms (Patel and Desai 2009). These three suspensionfeeder structures comprise a pioneer community of opportunists commonly displaying low diversity and high density of trace fossils. These burrows were produced over a short period of time and the depositional environment was inhospitable to most life forms. This may be attributed to oxygen depletion, variable salinity, uneven rates of sediment accumulation or merely a newly-deposited biologically-unconditioned substrate. *Ophiomorpha* is a deposit and/or suspension feeder (Ekdale 1992; Uchman and Ga´zdzicki 2006) and its traces are found in the shallow water environment in siliceous and calcareous sedimentary facies of post-Paleozoic ages (Pemberton and Jones 1988; Uchman and Ga´zdzicki 2006). In modern environment it is con sidered to be produced by crustaceans callianassid *Callianassa major* (Weimer and Hoyt 1964; Uchman and Ga´zdzicki 2006) and Stomatopodean shrimp *Oratosquilla striata* (Patel and Desai 2009).

Both *Ophiomorpha* and *Skolithos* are associated with environments characterized by frequent high-energy events, drastic changes in the sedimentation rate and erosion of surface sediments (Walker and James 1992; Singh *et al* 2008). Rocks of the Bhuban Formation also consists of horizontal, lined and unlined, branched and unbranched, dwelling and feeding burrows.

Thalassinoides burrows are mostly simple types of feeding and dwelling structures. These are normally considered typical of littoral environment with maximum water depth of *20* m. Trace fossils of the Laisong Formation, characteristically display the development of *Skolithos* ichnofacies typical of shallow marine settings (MacEachern *et al* 2007). *Ophiomorpha* and *Skolithos* are typically the member of the *Skolithos* ichnofacies and are characterized by trace fossils produced by suspension feeders. The characteristic suits of biogenic structures and sediment types indicate relatively moderate to high energy conditions and shifting substrate have been exploited by the opportunistic animals in the in the shallow marine environments. The *Skolithos* ichnofacies is associated with relatively high levels of wave or current energy and it is typically developed in clean well-sorted loose or shifting substrates. These conditions commonly occur on the shoreface

and sheltered foreshores but similar conditions occur also in a wide range of high-energy shallow-water environments (MacEachern *et al* 2007; Singh *et al* 2008).

5. Conclusions

A rich association of trace fossils in the Laisong Formation, Manipur are mainly found in *Trace fossils from* Laisong Formation, exposed in the Laimatol Hill of Thangjing Range, Manipur sandstone, silty-sandstone, silty-shale and shale lithologies. A total 7 ichnospecies of4 ichogenera were identified which are dominated by feeding burrows and trails. Ethologically the association represents domichnia and fodinichnia groups. The development of *Skolithos* and*Cruziana* ichnofacies in Laisong Formation rocks exposed at Laimaton , indicate sandy shifting substrate and high energy conditions in foreshore zone and unconsolidated, poorly sorted soft substrate and low energy condition.

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