

Fossil Gymnosperms from Barakar Formation of Raniganj Coalfield, West Bengal, India

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Abstract

The present paper deals with the fossil gymnosperms collected from Kalipahari Colliery (Barakar Formation, Early Permian) under the Raniganj Coalfield in the state of West Bengal, India. Systematic descriptions of the fossil gymnosperms collected from this colliery namely *Macrotæniopteris feddenii* Feistmantel belonging to Cycadales, *Vertebraria indica* Royle, *Glossopteris communis* Feistmantel, *Glossopteris damudica* Feistmantel, *Glossopteris indica* Schimper, *Glossopteris intermedia* Bunbury, *Glossopteris rhabdotaenioides* Pant and Singh and *Glossopteris vulgaris* Pant and Gupta belonging to Glossopteridales have been presented herein. In the present study the fossil assemblage is dominated mainly by the species of *Glossopteris*, although some species of the pteridophytes were also observed which indicates that this study area belongs to fossiliferous Upper Barakar Formation of Early Permian. The dominance of *Glossopteris* leaves and complete absence of gymnospermous seeds (associated or dispersed) further supports that the flora is mainly comparable with that of the Upper Barakar Formation. As the assemblage of Kalipahari Colliery shows dominance of glossopterids and includes *Macrotæniopteris*, a member of Cycadales, along with some pteridophytes, it becomes evident, therefore, that the palaeoclimate of this area was warm and humid that facilitated the growth of gymnosperms. The species of gymnosperms occurring in Kalipahari Colliery, Barakar Formation when compared with the flora of Barren Measures and Raniganj Formation studied by different authors, the occurrence of very similar plant assemblage was evident which indicate that the flora existed in the study area belonging to Barakar Formation continued to Barren Measures and became multifarious in Raniganj Formation with the development of many types of *Glossopteris* leaves and fructification.

Keywords: Fossil Gymnosperms, Early Permian, Kalipahari Colliery, Raniganj Coalfield, Barakar Formation, Damodar Basin

Introduction

Different authors have recovered fossil gymnosperms from different coalfields in India to reveal the diversity of such plants in this country. The fossil gymnosperms were investigated from various coalfields of India such as Maitur Formation of Raniganj Coalfield (Pal *et al.*, 2010), Raniganj Formation of Singrauli Coalfield (Singh and Saxena, 2015) and Pali Formation of Johila Coalfield (Pillai *et al.*, 2018) *etc.* Similarly, extensive palaeobotanical studies have been carried out in different collieries under the Raniganj Coalfield also which are situated in the state of West Bengal, India such as West Jamuria Colliery (Maheshwari, 1965), Mahabir Colliery (Maithy, 1974), Sonepur-Bazari Colliery (Mandal and Gupta, 2015) *etc.* But, it is necessary to investigate all the collieries under each coalfield to achieve a comprehensive list of total number of species of gymnosperms survived in India in the remote past. Keeping this view in mind palaeobotanical studies have been carried out in different collieries under different

coalfields. So far, no palaeobotanical study was undertaken in Kalipahari Colliery of West Bengal. Therefore, the present palaeobotanical study was carried out in this region during 2014-2015 and number of gymnosperm plant fossils belonging to Cycadales and Glossopteridales were recovered and discussed to ascertain the geologic age and palaeoclimatic conditions.

Geological Setting

The Kalipahari Colliery (23°39'55"N; 87°0'58"E) is located in Sripur Area of Asansol Subdivision in West Burdwan District of the state of West Bengal, India (Fig. 1a). It is an open cast coal mine project (OCP) (Fig. 1b-e) and situated about 10 km east of Asansol Railway Station, Eastern Railway, West Bengal. Kalipahari Colliery lies in the Damodar Basin between two rivers, the Damodar and the Ajay, which flow almost parallel to each other (Fig. 1). The Damodar River traverses the southern part of the Raniganj Coalfield flowing due east while the Ajay River entered West Bengal near Kalipahari and flows in the northern part of the Kalipahari Colliery. The Gondwana rocks in the Raniganj Coalfield are represented by Talchir, Barakar, Barren Measures, Raniganj and Panchet Formations (Murthy *et al.*, 2010).

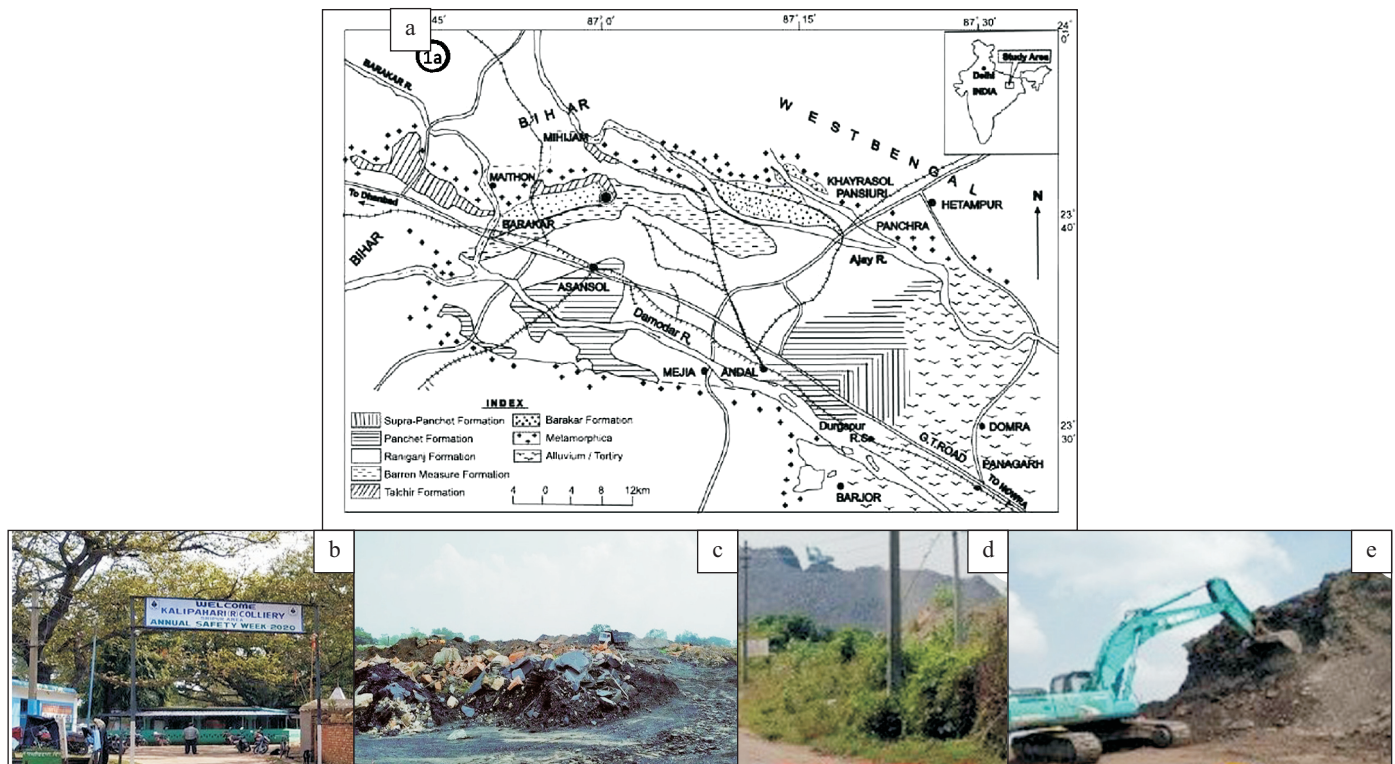


Fig.1 a. Geological map of Raniganj Coalfield showing the location of study area, b. Entry point of Kalipahari Colliery, c. Kalipahari Colliery (open cast project (OCP), d. Outside of Kalipahari OCP, e. Dumping site of Kalipahari OCP.

Materials and Methods

The fossilized materials are studied from Kalipahari Colliery (23°39'55"N; 87°0'58"E) which is situated near Kalipahari Railway Station, West Bengal, India (Fig.1). These materials were studied using ordinary hand lens and low power binocular. The finer details of the samples were studied after soaking the materials in xylol or kerosene oil. For identification of the specimens, their features have been compared with the authentic descriptions provided by different authors (Feistmantel, 1881, 1882; Goswami, 2006; Goswami and Singh, 2010; Pal *et al.*, 2010; Pant and Gupta, 1968; Pant and Singh, 1971; Pillai *et al.*, 2018; Royle, 1839; Singh and Saxena, 2015; Srivastava, 1979; Tewari, 2007, 2008). All the specimens are deposited in the repository of Palaeobotany and Palynology Section, Department of Botany, Burdwan Raj College (BRCP), University of Burdwan, West Bengal, India.

Systematic Paleontology

Macrotaeniopteris feddenii Feistmantel (Fig.2a)

Description

There is only one specimen in the present collection, leaf incomplete, apex and base not preserved, size of preserved specimen of leaf 13.5 × 5.9 cm, midrib 3 mm wide, secondary veins dense and very closely spaced, emerged from the midrib at an angle of 70°-80°, run almost parallel to each other and meet the margin at the same angle, veins slightly turned upwards near the margin, cross connection in between the veins and also the meshes absent in the leaf.

Comparison

The present specimen of *Macrotaeniopteris feddenii* shows close resemblance with the specimens described by Feistmantel (1881:Pl.21,fig.3; Pl.22, figs.1-4; 1882: Pl.21, fig.5) and Goswami and Singh (2010: Pl.II, fig.8).

Specific diagnostic features of *M. feddenii*

M. feddenii is specifically diagnosed by its thick mid-rib; venation non reticulate; secondary veins emerged from the midrib run parallel to each other.

Vertebraria indica Royle (Fig.2b-e)

Description

Four specimens are present in the collection. Size of preserved specimens 9.5-13.5 × 1.0-1.5 cm, consisting of 1.3-2.1 × 0.6-0.8 cm rectangular areas in two linear rows, separated by a median longitudinal furrow and the areas are transversely separated by grooves.

Comparison

The present specimens compare with the Holotype specimen described by Royle (1839) and Goswami (2006: Fig.3a).

Specific diagnostic features of *V. Indica*

Presence of rectangular grooved areas arranged in longitudinal rows.

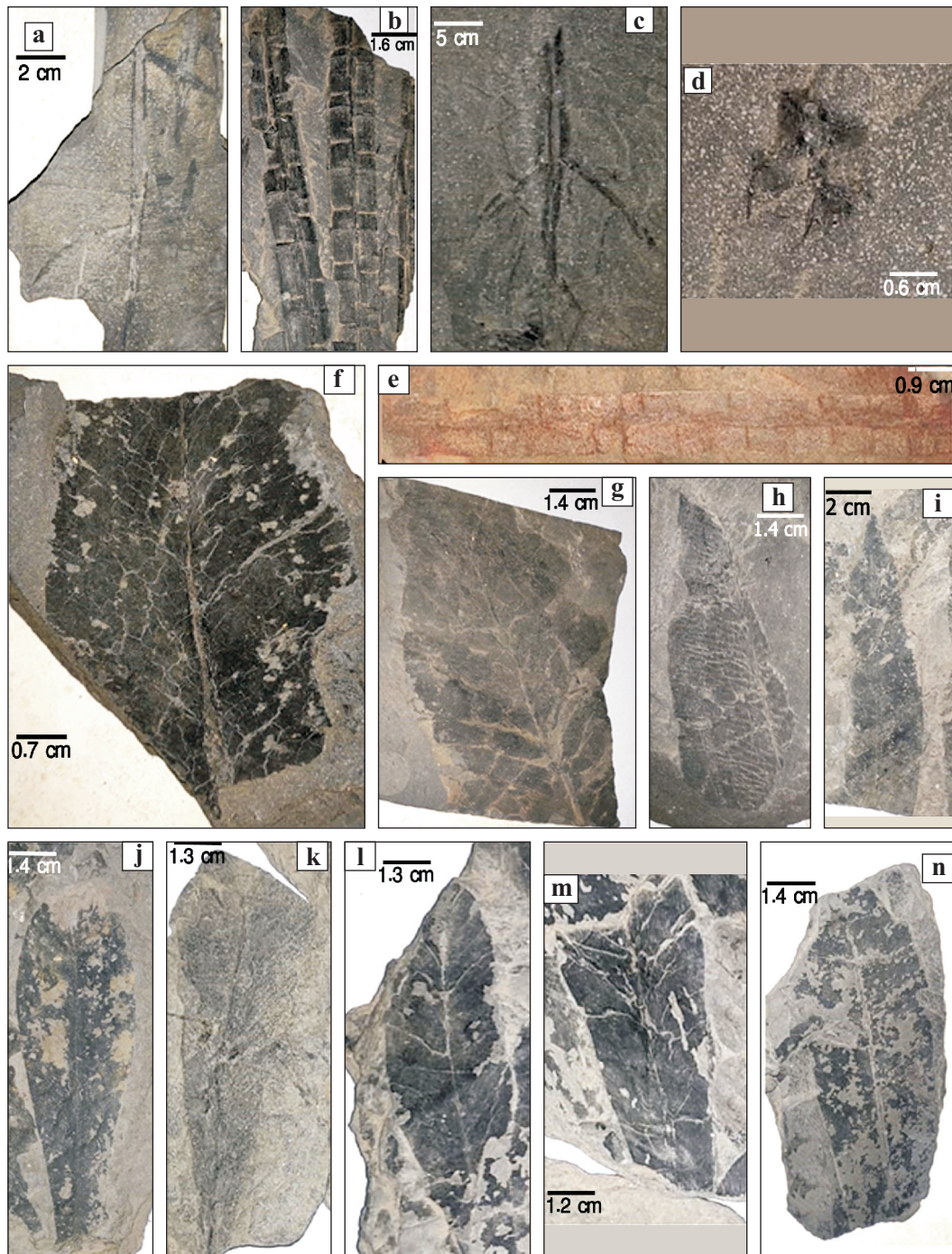


Fig.2 a. *Macrotaeniopteris feddenii* (Specimen No. BRCP-141); b-e. *Vertebraria indica* (Specimen Nos. BRCP-151, BRCP-154, BRCP-155, BRCP-156); f. *Glossopteris communis* (Specimen No. BRCP-142); g, h. *Glossopteris damudica* (Specimen Nos. BRCP-143, BRCP-145); i-n. *Glossopteris indica* (Specimen Nos. BRCP-152, BRCP-153, BRCP-156, BRCP-158, BRCP-159, BRCP-1510).

***Glossopteris communis* Feistmantel (Fig.2f)**

Description

Only one specimen is present in the collection. Leaf incomplete, apex and base not preserved. Size of preserved specimen of leaf 5.5 × 4.5 cm, broad in the middle and tapering towards apex and base, margin entire whenever preserved. Midrib flat, striated, strong, persistent, distinct, 3 mm wide towards the base, gradually tapering to 1 mm towards apex.

Comparison

The leaf is comparable with *Glossopteris communis* described by Feistmantel (1882: Pl.21, figs.13,14), Pillai *et al.* (2018: Pl.I, figs.3, 4), Singh and Saxena (2015: Pl.III, fig.4), Srivastava (1979: Pl. I, fig.1) and Tewari (2008: Pl.II, fig.7).

Specific diagnostic features of *G. communis*

Leaf lanceolate; midrib well developed, thick, persistent;

secondary veins arise at the acute angle and arch to form narrow meshes.

***Glossopteris damudica* Feistmantel** (Fig.2g, h)

Description

Two specimens are present in the collection. Size of preserved specimens of leaf 10-11 × 5.5-6.0 cm, leaves broadly lanceolate, apex acute to acuminate, base not preserved, margin entire. Midrib distinct, striated, strong, persistent, up to 3 mm wide towards the base, gradually tapering towards apex. Secondary veins arise at acute angle of about 45° from the midrib and meet the margin at angles of about 75°. Meshes are hexagonal in shape, broad and long near midrib and small and narrower near the margin.

Comparison

The leaves are comparable with *Glossopteris damudica* described by Feistmantel (1881: Pl.20, fig. 2; Pl.31, figs. 1-3) and Tewari *et al.* (2017: Pl.3, fig.3).

Specific diagnostic features of G. Damudica

Leaf broadly lanceolate, midrib distinct, meshes hexagonal.

***Glossopteris indica* Schimper** (Fig.2i-n)

Description

There are six specimens in the present collection, leaves incomplete, different portions of apical, middle and basal regions preserved separately. Shape of leaf lanceolate to oval-lanceolate, base narrowly attenuate, apex acute, margin entire, size of preserved specimens of leaf 5.7-12 × 2-3.6 cm, midrib flat, distinct, striated, strong, persistent, 2 mm wide towards the base, gradually thinning towards apex. Secondary veins arise at acute angle of about 45° from the midrib and form shorter meshes near the midrib and narrow elongate meshes towards the margin.

Comparison

The specimens resemble closely with the specimens of *Glossopteris indica* described by Pal *et al.* (2010:Pl.2, fig.13), Pillai

et al. (2018: Pl. I, fig.6), Singh and Saxena (2015: Pl. II, fig.3), Tewari (2007: Pl.4,fig.2).

Specific diagnostic features of G. Indica

Leaf oval-lanceolate with acute apex; midrib distinct; secondary veins forming narrow meshes.

***Glossopteris intermedia* Bunbury** (Fig.3a,b)

Description

Only two leaves are present in the collection. Leaves incomplete, apex and base not preserved. Size of preserved specimens of leaf 7.5 × 2.8 cm, margin entire, midrib striated, distinct, persistent, 2mm broad at base, thinning upwards, secondary veins arise at acute angles from midrib, run obliquely to meet the margin.

Comparison

The present specimens resemble closely with the specimens of *Glossopteris intermedia* described by Feistmantel (1881:Pl.29A, fig. 6), Pal *et al.* (2010: Pl.1, fig.12), Pillai *et al.* (2018: Pl. II, fig.1), and Tewari (2007: Pl.I, fig.8).

Specific diagnostic features of G. Intermedia

Leaf elliptic, midrib striated, secondary veins arise at acute angle from midrib.

***Glossopteris rhabdotaenioides* Pant and Singh** (Fig.3c)

Description

Single specimen present in the collection, almost middle portion of lamina preserved without base and apex, margin entire, size of preserved specimens of leaf 9 × 7.5cm, midrib striated, 2mm wide at basal part, gradually thinning upwards, secondary veins arise from midrib perpendicularly and run straight to meet margin after dichotomization and anastomoses.

Comparison

The specimen is comparable with *Glossopteris*

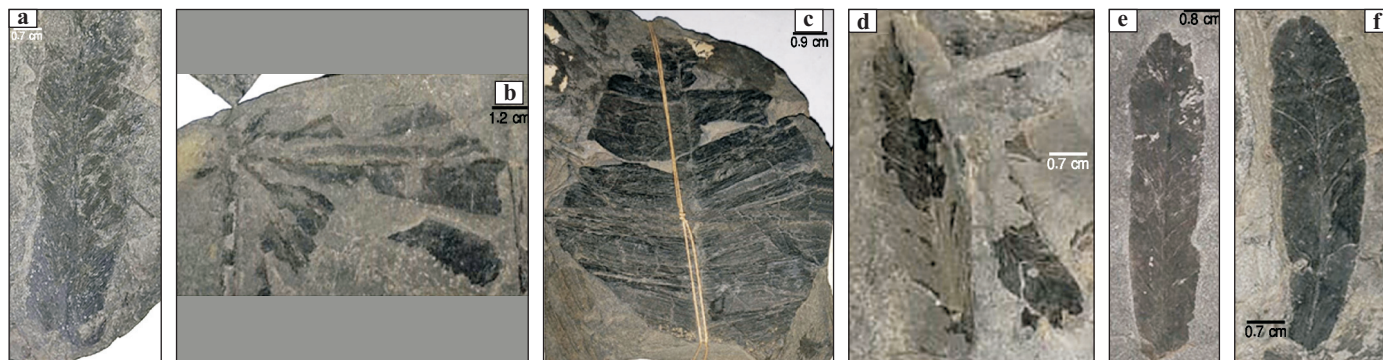


Fig. 3. a-b. *Glossopteris intermedia* (Specimen Nos. BRCP-146, BRCP-149); c. *Glossopteris rhabdotaenioides* (Specimen No. BRCP-144); d-f. *Glossopteris vulgaris* (Specimen Nos. BRCP-147, BRCP-148, BRCP-1410).

rhabdotaenioides described by Pant and Singh (1971: Pl. 7, figs. 41, 45), Tewari (2008: Pl. III, fig. 6).

Specific diagnostic features of G. rhabdotaenioides

Leaf broad, midrib distinct, secondary veins perpendicular to midrib and run straight to meet margin.

***Glossopteris vulgaris* Pant and Gupta (Fig.3d-f)**

Description

Three specimens present in the collection, leaf incomplete, basal part of two leaves not preserved, leaf narrow, margin entire, apex narrowly obtuse, size of preserved specimens of leaves 5.6-5.8 × 1.5-1.7cm, midrib thin, 1.5mm wide, flat, secondary veins arise at acute angles from midrib, run straight to meet margin after dichotomization and anastomoses.

Comparison

The specimens resemble with *Glossopteris vulgaris* described by Pant and Gupta (1968: Pl.24, fig.34), Pillai *et al.* (2018: Pl.III, fig.8), and Tewari (2008: Pl.II, fig.8).

Specific diagnostic features of G. vulgaris

Leaf linear-oblong, midrib thin, secondary veins arise at acute angle.

Discussion

It is the first comprehensive record of the fossil gymnosperm flora from the Barakar Formation (Early Permian) of the Kalipahari Colliery under the Raniganj Coalfield in the state of West Bengal, India. Barakar Formation belonging to Early Permian age lies over the Kaharbari Formation (Jha and Sinha, 2022). However, a few species of pteridophytes were collected along with many species of gymnosperms from Kalipahari Colliery, which indicates that gymnosperms dominated over pteridophytes in this area during the Early Permian. Among the gymnosperms, Glossopteridales dominated the assemblage and represented by six species of *Glossopteris*. Goswami *et al.* (2006) in a study of pteridophytes differentiated Barakar Formation into (i) Lower Barakar Formation which is characterized by complete absence of any pteridophyte, and (ii) Upper Barakar (younger fossiliferous bed) which is rich in pteridophytes. Kalipahari Colliery having some pteridophytes has been treated as a piece of land belonging to Upper Barakar Formations following Goswami *et al.* (2006). Therefore, from megafossil composition it is evident that Kalipahari Colliery belongs to Upper Barakar Formation of Lower Permian. The dominance of *Glossopteris* leaves and complete absences of gymnospermous seeds (associated or dispersed) further suggests that the flora is mainly comparable with that of the Upper Barakar Formation (Srivastava, 1997).

Of the eight species of gymnosperms collected namely *Macrotaeniopteris feddenii* Feistmantel belonging to Cycadales, *Vertebraria indica* Royle, *Glossopteris communis* Feistmantel, *Glossopteris damudica* Feistmantel, *Glossopteris indica* Schimper, *Glossopteris intermedia* Bunbury, *Glossopteris rhabdotaenioides*

Pant and Singh and *Glossopteris vulgaris* Pant and Gupta belonging to Glossopteridales were all reported previously from different collieries under Barakar Formation (Goswami and Singh, 2010; Pillai *et al.*, 2018; Tewari *et al.*, 2017). Excepting *G. intermedia* and *G. rhabdotaenioides*, assemblage of all other four species belonging to Glossopteridales is comparable with those described from the Lower Gondwana basins of India such as Damodar, Mahanadi, Wardha, Satpura and South Rewa Basins (Tewari *et al.*, 2017). *G. rhabdotaenioides* has been recorded only from Barakar Formation of the Damodar Basin (Tewari *et al.*, 2017) and it is the second report of *G. rhabdotaenioides* from this basin. Pal *et al.* (2010) reported *Glossopteris intermedia* from Maitur Formation in Raniganj Coalfield. In the present study, this species has been collected from Barakar Formation. Besides, *Glossopteris vulgaris* has been collected from Kalipahari Colliery which is endemic to India and is distributed in Barakar, Raniganj and Kamthi Formations (Pillai *et al.*, 2018; Sahoo *et al.*, 2024).

As the assemblage of Kalipahari Colliery shows dominance of glossopterids and includes *Macrotaeniopteris*, a member of Cycadales, along with some pteridophytes, it becomes evident, therefore, that the palaeoclimate of this area was warm and humid that facilitated the growth of gymnosperms (Gautam *et al.*, 2022). The gymnosperms of Barakar Formation occurring in Kalipahari Colliery when compared with the flora of Barren Measures (Chopparapu *et al.*, 2019) and Raniganj Formation (Pillai *et al.*, 2018), very similar plant assemblage was evident which indicated that the flora existed in the study area belong to Upper Barakar Formation continued to Barren Measures and became multifarious in Raniganj Formation with the development of many types of *Glossopteris* leaves and fructification.

Conclusions

The paper documents eight species of gymnosperms namely *Macrotaeniopteris feddenii* Feistmantel belonging to Cycadales, *Vertebraria indica* Royle, *Glossopteris communis* Feistmantel, *Glossopteris damudica* Feistmantel, *Glossopteris indica* Schimper, *Glossopteris intermedia* Bunbury, *Glossopteris rhabdotaenioides* Pant and Singh and *Glossopteris vulgaris* Pant and Gupta belonging to Glossopteridales. From the study of megafloreal assemblage of Kalipahari Colliery it is evident that the gymnosperms inhabited in this region belong to Upper Barakar Formation belonging to Lower Permian age. Palaeoclimate of the region was warm and humid which supported survival of glossopterids on the one hand and pteridophytes and cycads on the other.

Conflict of Interest

The Author declares no conflicts of interest.

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