Regeneration is a process that requires more energy compared to that required for growth of the animal[13]. Marine animals are capable of differentially allocating nutrients to different functions of body such as maintenance, metabolism, somatic growth, wound repair and reproductive tissue growth. The allocation is a dynamic process depending on the physiological and reproductive states of the organisms[14,15].

It has been a well-known fact that the crustaceans are able to re-grow their limbs and regenerate muscle fibres. The discovery of the factors responsible for regeneration may provide vital information to determine how to replicate such a process with human tissues. The implications of this for human health are enormous because crustacean muscles seem remarkably similar to humans. Protein structure in human is almost the same and the crustacean molecular switches work the same way as human muscles do.

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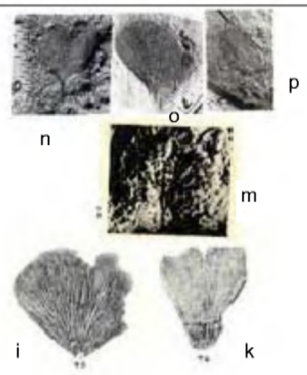
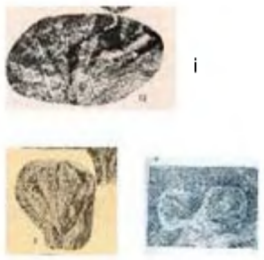
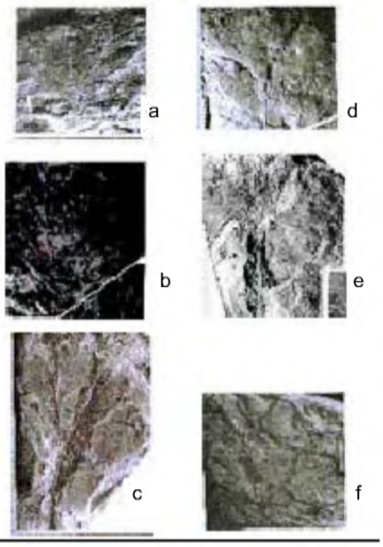
Occurrence of *Ginkgo* Linn. in Early Cretaceous deposits of South Rewa Basin, Madhya Pradesh

Ginkgo biloba Linn. (maiden-hair tree), the only extant species of Ginkgoales shows several ancestors in fossil records. It is the sole living member among the race of dominant plants that probably existed on the earth longer than any other tree. It has a long fossil history ranging from the Late Permian (270–255 million years) to modern time and achieved its maximum diversity during the Jurassic (240–255 m.a.) period[1,2]. They have mostly been reported from the northern hemisphere, but also occur in the Gondwana deposits[3]. In India, the earliest record goes back to the Permian of the Rajmahal Basin[4]. The Triassic beds of South Rewa Basin also yield *Ginkgo*-like leaves[2,5,6], but definite Ginkgoales were recorded from Jurassic beds of Rajmahal Basin[7]. Many forms of leaves and ovules of *Ginkgo* from the Early Cretaceous deposits are virtually unchanged till modern time.

The order Ginkgoales in the Mesozoic deposits is represented by leaf remains and ovules attributed to *Ginkgo* and *Ginkgoites*. Although quite meagre in fossil forms, their records indicate that they were morphologically diversified before the Early Cretaceous. Therefore, we can say that the Mesozoic witnessed the zenith of Ginkgoales along with other plant groups like Cycadales, Bennettitales and Coniferales. The other plant groups declined during Middle Cretaceous and most of them became extinct before the end of the Cretaceous[8], but Ginkgoales along with Coniferales and Cycadales survived in later periods. The Early Cretaceous remains of Ginkgoales represent a few species which show much similarity as the fossil and modern taxa of other plant groups like Coniferales and Cycadales. The appearance of Ginkgoales in India during Early Cretaceous is significant. Therefore, the present study is aimed to trace its lineage from the earliest record of fossils from the Permian to Early Cretaceous.

In context to the Indian fossil wealth, the appearance of Ginkgoalean leaves occurred during Late Permian[4]: *Rhipidopsis densinervis*, *R. gondwanensis*, *Ginkgoites veekaysinghii*, *G. huraensis*, *Saportaea reniformoides* and *Psygmophyllum kidstonii*. The Triassic genera reported from Goira (Shahdol District, Madhya Pradesh (MP) is *Ginkgoites goiraensis*[6] and *Ginkgo*-like leaves from South Rewa Gondwana Basin[2]. The Jurassic forms of *Ginkgo* are reported from Rajmahal Hills, i.e. *Ginkgo rajmahlensis*[9–11]. Later, records were made from different Early Cretaceous beds: *Ginkgoites lobata* from Satpura Basin[12,13], *G. crassipes* from Sriperambudur beds[13] and *G. cressipes*[14] and *G. feistmantalii*[15] from Bansa, South Rewa Basin. *G. feistamantli* was also reported from Ragha-

Table 1. Characters of fossil leaf lamina recorded in various geological periods[2,4,6,7,9–11,15]

Epoch	Characteristic feature	Leaf and ovule of various taxa
Early Cretaceous	Leaf form variable, lamina obovate, orbicular or oval, 1.8 × 2.5 cm in size, margin entire with single notch at upper margin. Lower margin prolonged to a fairly long petiole. Two forks of the strand dichotomizing repeatedly forming few veins[15]. Cuticle thin. Cell walls not visible. Faint impressions of cutinized guard cells. Stomata irregularly distributed. (k) *Ginkgoites lobata*, (l) *Ginkgoites crassipes*, (m) *Ginkgoites feistmantelii*, (n, o) *Ginkgo biloba* and (p) Ovule of *Ginkgo biloba.*	
Jurassic	Lamina wedge-shaped or obcuneate, 2–6 × 2.5–6 cm in size, dissected into 8–12 segments. Segments linear, spatulate or club-shaped, apex rounded, margin entire. Cells along veins serially arranged, rectangular with slightly wavy, lateral and end walls. Between veins stomata irregularly distributed. (i) *Ginkgo rajmahalensis*[6], (j) *G. rajmahalensis*[7,9–11]. Fruit size 5–6 × 7–8 mm, sessile, radially symmetrical, ovate.	
Triassic	Leaf large, petiole semiarbicular, lamina segmented, incision up to half radius deep, dichotomizing at various levels. Lamina apically incised about 4 mm deep. (g) *Ginkgoites goiraensis*, (h) *Ginkgo*-like leaves[6].	
Permian	(a) Leaves fan-shaped attached to shoot in loose spiral, 6–8 lamina, 3.5–5 × 4–9.5 cm. Petiole large, more or less oval leaves. Venation dense – *Rhipidopsis densinervis.* (b) Leaves petiolate, lamina fan-shaped, 5–6.1 × 6.1–6.5 cm palmately dissected, veins dichotomously branched–*Gingkgoites veekaysinghii*. (c) Leaves broadly fan-shaped, attached helically to shoot, flabelliform, 6–10 segments, elongate–oval, veins dichotomizing 3–5 times–*Rhipidopsis gondwanensis*. (d) Lamina fan-shaped, 6.5–12.5 × 5–6.8 cm in size, reniform, base cuneate or wedge-shaped. Veins dichotomizing 3–4 times–*Ginkgoites huraensis.* (e) Leaf petiolate, lamina 3.4–6.8 × 6.5–10.8 cm, flabellate in shape, margin entire–*Saportaea reniformoides*. (f) Leafy shoot, cuneate, flabellate, bilobed leaves in a loose spiral – *Psygmophyllum kidstonii.*	

vpuram mudstone[16]. However, earlier there was no uniform opinion regarding the nomenclature of the genus; as Feistmantle[12] described fossil leaves resembling *Ginkgo* as *Ginkgo biloba.* Later Seward[17], and Seward and Sahni[13] redescribed the same as *Ginkgoites*, which was redefined by Harris[18] as, 'leaves divided in two or more lobes by shallow notches never reaching the basal part of the lamina as in *Ginkgo*'.

The specimens used for present study have been collected from a clay quarry pit

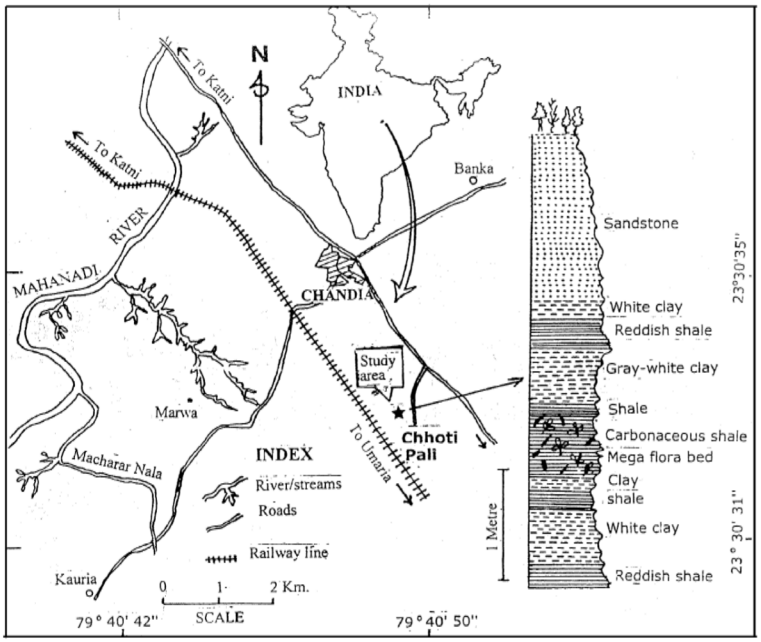


Figure 1. Location of area and litholog of the section from where fossil leaves of *Ginkgo* were collected.

section at Chhoti Pali village situated 4 km southwest of Chandia (long 78°40′42″–79°40′50″: lat 23°30′31″–23°30′35″), District Umaria (MP), South Rewa Gondwan Basin (Figure 1). Some leaf impressions have been collected from 50 to 52 cm thick, partially silicified greyish-carbonaceous shales of Jabalpur Formation (Early Cretaceous). This horizontally stretched bed is sandwiched between grey shale and clay which is overlain by reddish shale, white clay and 1.6 m thick sandy bed. The other flora recorded from these beds comprise of *Gleichenia*, *Cladophlebis*, *Ptilophyllum*, *Elatocladus*, *Allocladus*, *Araucarites* and *Desmiophyllum*. The floral assemblage is mostly dominated by *Gleichenia* and *Ginkgo* leaves.

Leaves of the fossil specimens are variable in size and shape. Lamina obovate or oval, typically 1.2–2.7 cm long and 0.8–2.5 cm wide. Margin almost entire, mostly with a single notch at the apex. Lower margin prolonged to a very long petiole measuring 0.8 cm × 2 mm with a single dark strand dichotomizing just below the lamina. After a short distance two forks of the strand dichotomize repeatedly forming few veins that also dichotomize near the margin. However, modern leaves show variability in their size, shape and dissected apical margin (Figure 2 *a*, *e* and *f*).

Several matured ovule specimens were also collected from the same bed. They are 1.8 × 0.8–1.2 cm in size, oval to elliptical in shape. The surface shows regular folds probably belonging to integuments (Figure 2 *g* and *h*).

The specimens reported from Permian–Early Cretaceous are fan-shaped to deeply divided and ultimately less divided with undulate to nearly entire margin. The morphological changes in lamina recorded in various geological ages may have been caused by planation, webbing and fusion of telomes and mesomes[13]. An evolutionary trend is also visible in Ginkgolean seeds as the mature ovules grow in size and reduce in number due to reduction in ovule and pedicel. They tend to become contiguous by virtue of shortening and eventual loss of the pedicel.

Table 1 shows the features of fossil lamina recorded at various geological periods.

It is inferred that the Early Cretaceous leaves of *Ginkgo* from Jabalpur Formation in South Rewa Basin are more evolutionarily advanced than the deeply dissected leaves of *Ginkgoites rajmahalensis*[7].

The fossil records of *Ginkgo* highlight its longest survival history. Its known fossil-bearing localities are few in India as well as in other parts of the world. Its presence in various sedimentary deposits indicates that the taxa of Ginkgoales were growing with diversified species mostly at uplands (not montane) associated with sandy channels[19]. The lithological and palaeobotanical features of the Ginkgoalean beds indicate that they grew in undisturbed environment of uplands situated along the freshwater stream margins, associating flood plain settings and steep slopes[21], where other phytoassemblage like Coniferales, Cycadales and Bennettitales were also thriving. All these forms recorded at Chhoti Pali in association with Ginkgoales indicate prevalence of similar habitat. The modern *Ginkgo* is typically shade-intolerant, growing best at exposed sites. It is surprising how this plant has persisted unchanged over many million years unlike a large number of its associates like Bennettitales Coniferales, Caytoniales, Cycadales, etc. which did not survive except some Conifers on the rise of angiosperm diversity. Obviously, it has been eminently suited to the environment due to its nature of adaptability and resistance against pathogens.

With reference to break-up of Pangea, its record in geologic past is more important than its presence in modern times. The Permian[4] forms show some primitive characters, which align it to the family

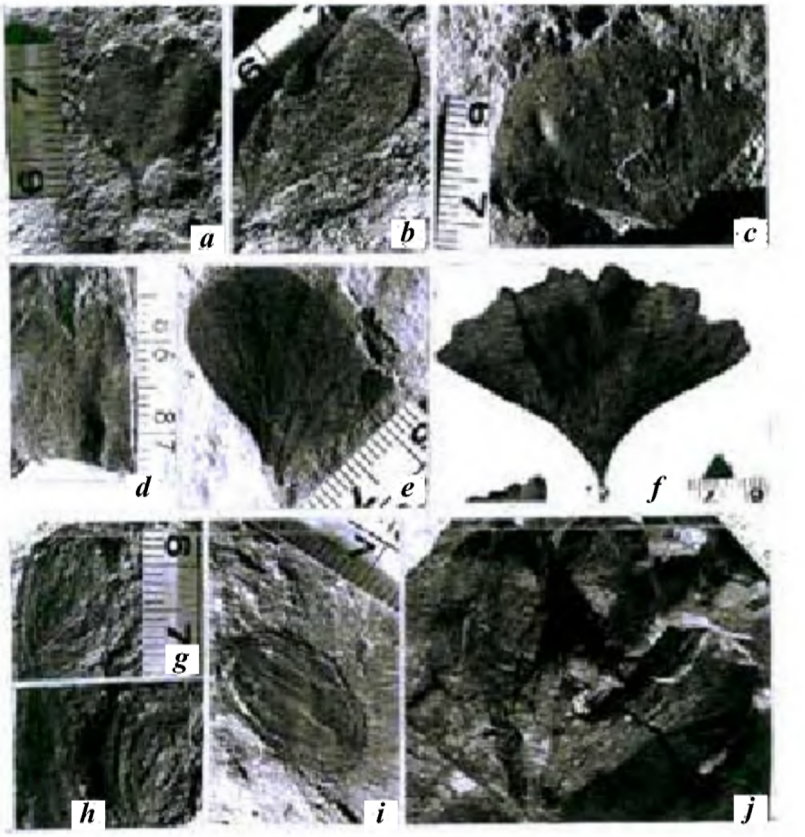


Figure 2. Leaf impressions of *Ginkgo* from Early Cretaceous beds of South Rewa Basin, ***a***, Bilobed pinnule and a central apical notch; BSIP specimen no. 39108 × 2, ***b***, ***e***, Venation pattern of *G. biloba*; BSIP specimen nos 39109 and 39111 × 2, ***c***, Shape of leaf margin resembling extant leaf of *G. biloba*. ***d***, Ginkgoalean leaf from Triassic of South Rewa Basin[2]; BSIP specimen no. 8887 × 2, *f*, leaf lamina of modern *G. bilota*, ***g–i***, Seed impressions of *G. biloba*, surface showing regular folds/concentric outline; BSIP specimen nos 39112 and 39114 × 2, ***j***, Leaf impression of *Ginkgoites rajmahlensis* from Jurassic of Rajmahal Basin[7]; BSIP specimen no. 36/1248.

Ginkgoaceae. However, in the Jurassic period, the plant attained its greatest diversity and prominence in various continents. It attained its climax during this period and declined rapidly at the end of Early Cretaceous perhaps due to the break-up of Gondwana continents and drifting of the Indian plate towards the equator. This phenomenon affected greatly the destiny of *Ginkgo* and its evolution restricting the Ginkgoalean forests to subtropical to temperate regions. Later on the Ginkgoales have been eliminated from many continents, except Peoples Republic of China where single species, *Ginkgo biloba* is still surviving[20].

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