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Capers: A food for Upper Cretaceous dinosaurs of Pisdura, India

Pisdura, a well-known Upper Cretaceous dinosaur locality in Warora district, Maharashtra is known for reptilian coprolites. Based on their external morphology, coprolites can be grouped under four main types (A, B, Ba, C)[1]. Coprolites described by various workers[1–3] from this area contain exclusively vegetal matter and their association with titanosaurid sauropod skeletal remains reflects that these animals were the producers[1,4–9]. Though recovery of plant remains from these coprolites is scarce and fragmentary, a few records of megaflora (dicots and monocots, including pollen and cuticles) have also been described[5,6,8]. Presence of monocotylednous seeds belonging to the family Arecaceae was reported earlier[10]. Recovery of grass phytoliths from all known categories of coprolites mentioned above suggests that Late Cretaceous titanosaurid sauropods of Pisdura were grass-eaters and grass was present during the Late Cretaceous[9]. Occurrence of chelonians has been reported from the Lameta Formation of Pisdura[11,12]. It is likely that other carnivorous reptiles also must have been thriving in the same phytozones.

The present fossil coprolite described here was recovered from Pisdura, 3 km east of Temurda village in Maharashtra (Figure 1). The locality falls under the Dongargaon–Pisdura area where the sediments are best exposed at Pisdura for recovery of coprolites. The formation is overlain by Deccan volcanic rocks associated with thin intertrappean beds. The Lameta Formation chiefly comprises red and green silty clays, planar and cross-bedded sandstones, grey marls and yellow laminated clays and shales interbedded with marlites and limestones. The formation rests over Precambrian rocks[13,14]. The coprolite which is a broken part of some bigger specimen (probably type-A)

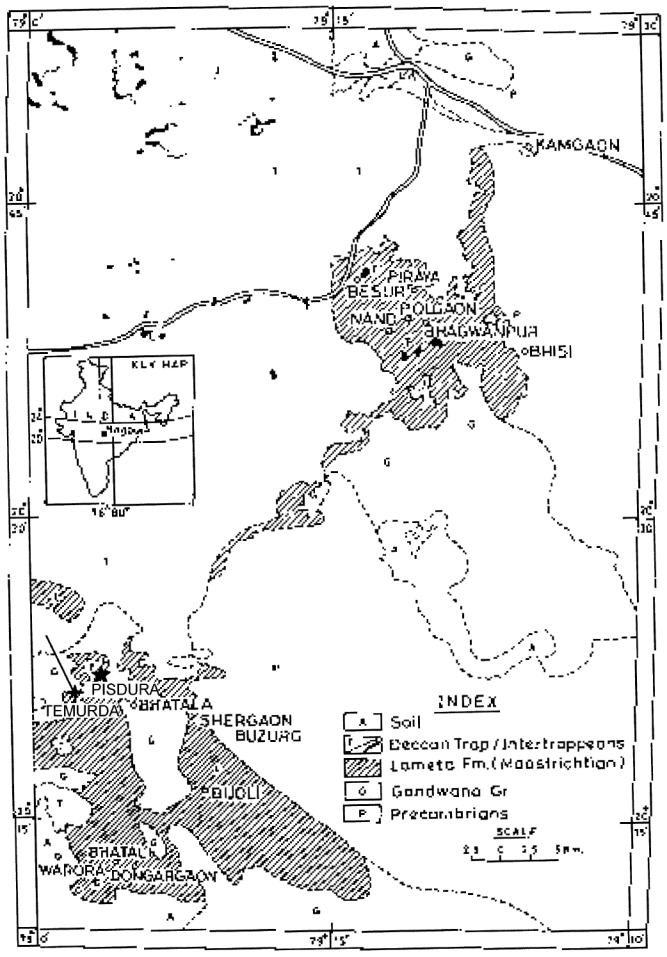

Figure 1. Map showing location and lithology of the area from where coprolites were collected (after Mohabey[13]).

is smooth in texture, about 4.5 cm long and 2.8 cm broad. One of the ends of the specimen is irregular, while the other end shows squeezing of the droppings providing an elevated surface. A few dispersed seeds adhere to one of the ends (Figure 2 *a*, *b*). Three to four seeds are complete, while in the remaining, the seed coat is partly broken (due to mechanical injury or dissolved in the alimentary canal; Figure 2 *d*). Seeds are generally reniform, and sometimes slightly triangular in shape. Presence of black (probably organic) matter associated to the seeds suggests that they were enclosed in a common fruit wall (a capsule or berry). The pericarp and pulp of the fruit seem to have disintegrated during the digestion process, leaving the harder undigested seeds in the alimentary canal, which on excretion remained intact. The size of the seeds varies from 3 to 4 mm in length and 2 to 2.5 mm in breadth. Seed coat (endocarp) is thin and smooth, 0.5 mm thick without any observable surface sculpture and cells of the endosperm are more or less ruminated (Figure 2 *d*).

Among the angiosperm families, fruits with many seeded capsules are also found in Annonaceae, Crucifereae, Cistaceae, Cyclanthaceae, Droseraceae, Ericaceae, Linaceae, Violaceae and Xyridaceae. It is noteworthy that seeds of these families are generally round to oval and sometimes triangular in shape; their size in relation to the fossil is either small or large. Morphologically the fossil seeds show affinities with seeds of the family Capparidaceae. They are generally reniform in *Capparis* and *Crateva* while horse-shoe shape with open cleft in *Cleome*, and range up to 8 mm long. It is found that the small reniform seeds measuring up to 5 mm are present both in *Capparis zeylenica* and *Crateva religiosa*[15–18] (Figure 2 *c*, *e*). The shape and size with smooth seed coat in the fossil seeds compare well with the above species, being reniform in shape and 3–5 mm in length.

A part of the coprolite was macerated for recovery of undigested plant material. However, no cellular plant structures could be seen, but a few siliceous crystals (phytoliths) were present. These phytoliths were sometimes in the form of individual crystals or in a group (Figure 2 *f*). Similar crystals were also observed in the extant fruits of *C. religiosa*, family Capparidaceae (Figure 2 *g*). Since the siliceous components of the plants could not be digested in the alimentary canal of the animal, they were excreted along with the scat. Occurrence of phytoliths further supports the affinities of the fossil to the extant taxon (*C. religeosa*). It seems obvious that plants of the family Capparidaceae similar to *C. religiosa* were common in this region.

The family Capparidaceae is represented by herbs, shrubs and trees, including 46 genera and about 700 species distributed palaeotropically in both hemispheres. Among these, 3 genera belong to Australia, 15 are indigenous to the New World and the rest belong to Eurasia. The most important genera, viz. *Capparis* (350 spp.), *Cleome* (200 spp.) and *Crateva* (20 spp.) generally grow in tropical regions of the world, whereas other taxa (*Cristatella* and *Wislizenia oxystylis*) are widespread in distribution, but *Cristatella* inhabits dry arid habitats[19,20].

According to Croizat[21], the family Capparidaceae probably evolved during Mid-Cretaceous as undifferentiated sires (male ancestors). However, during the Upper Cretaceous the family established in the African continent from where it made its way to the Indian subcontinent[21,22], and consequently appeared in the central part of India.

Fossil angiosperm leaves belonging to the family Capparidaceae are known from the Upper Cretaceous (grey-clay deposits) of the Old Crossman Clay Mine, Sayreville, New Jersey[23]. With regard to the Indian subcontinent, fossil leaves (*Capparis palaeomicrantha*) are known from the Lower Siwalik Formation (Middle Miocene) of Kathgodam, Nainital[24]. Recovery of Capparidaceae seeds in dinosaurian coprolites of the Lameta Formation constitutes one of the oldest records.

Figure 2. ***a***, Specimen showing fossil seeds adhered to coprolite. ***b***, Same specimen in front view showing seeds. ***c***, Sectional view of extant fruit (*Crateva religiosa*) showing nature and arrangement of reniform seeds in a capsule. ***d***, Part of the specimen enlarged showing reniform shape of seeds and smooth seed coat. ***e***, Seeds of *C. religiosa* showing reniform shape and smooth seed coat. ***f***, Crystals in fossil coprolite. ***g***, Crystals in *C. religiosa*. ***a–c***, Bar = 1 cm; ***d***, ***e***, Bar = 1 mm and ***f***, ***g***, Bar = 10 μm.

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