

for this protocol was reported to amplify a 687-bp region (from base pair 1055 to 1741) of the total *Pot2* element for the specific detection of only the non-rice strains of *M. grisea*⁵. The results of the PCR assay were quite reproducible for amplification of the 687-bp fragment in *Setaria*-infecting *M. grisea*, suggesting that this amplified region of the genome is common to *M. grisea* isolates that infect perennial ryegrass and foxtail millet. This specific detection procedure is also rapid and can be concluded within 3–4 h.

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Seedling mortality in two vulnerable tree species in the sacred groves of Western Ghats, South India

Sacred groves form a significant component of the traditional conservation movement in many parts of the tropical world¹. The Western Ghats, one of the two mega-diversity centers in India, is dotted with sacred groves, with the highest concentrations located in the central Western Ghats². Sacred groves are believed to serve as the last refugia for a number of taxa, particularly for rare, endangered and threatened species^{3,4}. Of late due to encroachments and land-use changes, the sacred groves have been increasingly threatened and fragmented⁴. During the last century alone, the total area under the groves in Kodagu district in the central Western Ghats decreased by 42%. Besides, more than 46% of the sacred groves in the district are less than 0.4 ha in area. The increased fragmentation of the groves could undermine the utility of these groves in serving as a refugium for the rare, endangered and threatened (RET) species. Here we examine the effects of grove area on the seedling mortality of two economically important and vulnerable tree species.

The study was conducted in the sacred groves of Ponnampet range (12°N, 75°E), Kodagu district in the central Western Ghats of India (Figure 1). The groves are set against a matrix of coffee plantation and agricultural landscape^{6,7}. The vegetation of the groves is predominantly evergreen, with a small proportion of semi-evergreen and deciduous patches. The sacred groves

within 20-km radius of Ponnampet were visited and 15 groves with area ranging from 0.37 to 11.28 ha were selected for the study. The latitude and longitude of the sacred groves were recorded using a global positioning system (GPS) and digitized using GIS software (MAPINFO)⁸. Based on the GPS data, inter-grove distance was estimated for each grove.

The study was conducted on two economically important and vulnerable tree species. *Artocarpus hirsutus* Lam. (Moraceae) is a dominant canopy tree, vulnerable globally⁹ and endemic to the Western Ghats¹⁰. The fruits are yellow, ovoid, covered with spines, containing numerous white seeds, 0.5–0.75 inches long with viability period of three weeks¹¹. Because of its edible fruit collection and extensive harvesting of highly prized timber, *A. hirsutus* has been threatened in the Western Ghats. *Canarium strictum* Roxb. (Burseraceae) is reportedly vulnerable in Karnataka⁹ and is known for its medicinal resin⁶. Fruits are ovoid or ellipsoid, often-trigonous drupe with 1–3 celled, 1–3 seeded stone¹¹. *C. strictum* is being mainly threatened for its valuable resin extracted by partially burning the trees. The species is distributed sparsely in the evergreen forests of the Western Ghats and Eastern Himalaya in India¹⁰. Both species are pollinated by small insects and are animal-dispersed.

Seeds or fruits of both species were collected from randomly chosen trees

from groves ($n = 13$ groves for *Artocarpus*, and $n = 11$ groves for *Canarium*). The seeds/fruits of the trees were collected during the respective fruiting phenologies (for *Canarium strictum* during January–February while for *Artocarpus hirsutus* during May–June). Immediately after collection, seeds/fruits were washed, weighed and a number of seed/fruit parameters (such as seed abortion, seed predation, etc.) were determined.

Sufficient care was taken to avoid sampling errors, including over- or under-representation for samples across the grove area. The seeds were sown separately in polythene bags filled with soil mixture, and allowed to germinate under shade in greenhouse conditions. Aborted seeds that were rudimentary and sclerotized were not considered. The germination percentage was calculated as the ratio of number of seeds germinated to the total number of sown seeds. The ratio of the number of dead seedlings (two months after germination for *Artocarpus* and three months for *Canarium*) to the total number of germinated seeds was computed for each grove and referred to as per cent seedling mortality.

We found a significant decline in per cent seedling mortality with increase in area of the grove ($P < 0.05$ in both the species; Figure 2a and b). For *Artocarpus*, the per cent seedling mortality ranged from as high as 100% in the small groves to none in the large groves. On the other hand, for

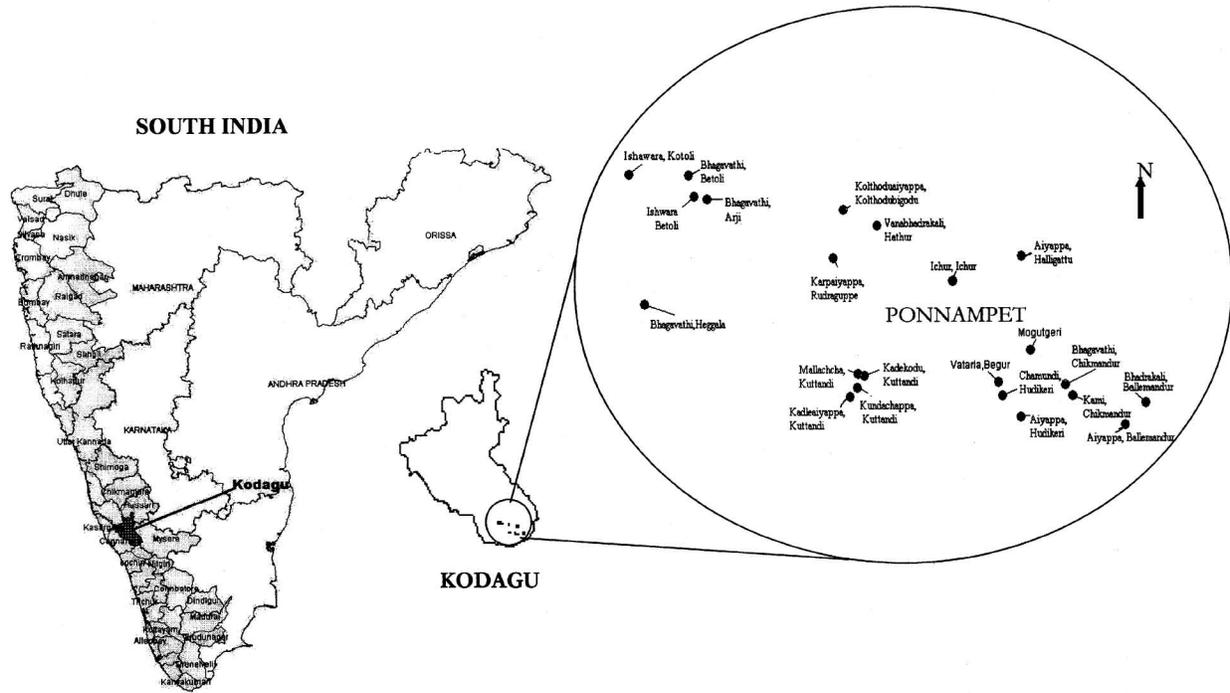


Figure 1. Distribution map of study sites (sacred groves) in Kodagu district, central Western Ghats, India.

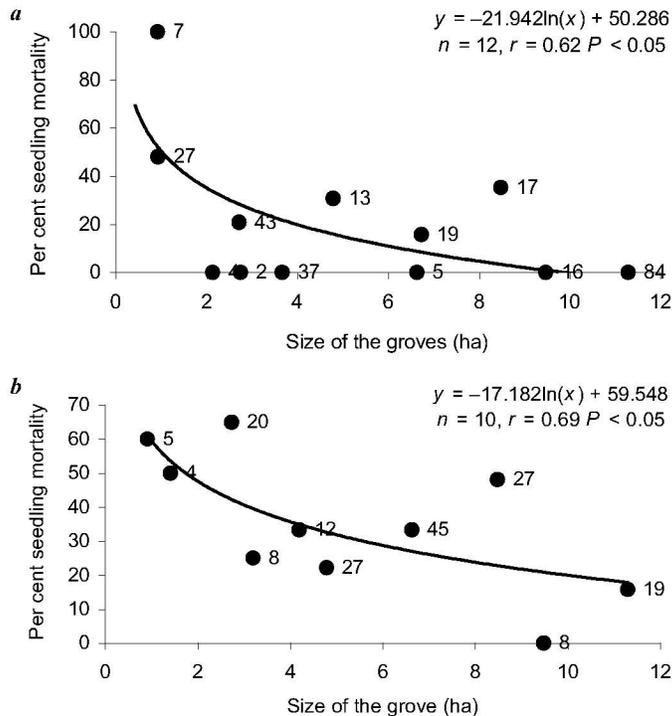


Figure 2. Per cent mortality of seedling (a) *Artocarpus hirsutus* and (b) *Canarium strictum* across grove area. Data points from 1.411 ha grove for *Artocarpus* and 2.711 ha grove for *Canarium* are not included in the regression analysis, since only single seedling was recovered from these groves. Numbers next to datapoint indicate number of seedlings used for analysis from that grove.

Canarium the mortality ranged from about 60% in the smaller groves to about 10% in the larger groves. Per cent seed germination increased nonlinearly with grove area though not significantly (for *Artocarpus* $y = 9.59\ln(x) + 41.014$, $R^2 = 0.070$ and for *Canarium* $y = 3.72\ln(x) + 11.37$, $R^2 = 0.111$).

Thus, in both species, seedling fitness decreased with increased fragmentation of sacred groves. Seedling mortality was not correlated to other seed features such as seed weight or seed predation. There was no significant differences in the densities of adult trees of both species across the size of the groves; however it likely that the smaller groves harbour fewer individuals compared to the larger groves. Thus the observed increase in per cent seedling mortality with decrease in grove size could be due to the closed mating among the fewer individuals in the small groves compared to the large. The average distance separating the selected groves is about 6.5 km, a distance that might constrain pollinator movements such as small insects (e.g. moths in *Artocarpus* and flies in *Canarium*). Thus the increased mortality in the smaller groves could reflect the consequences of inbreeding and the accumulation of developmental lethals. While the consequences of fragmentation on seed-

ling fitness are well known and have been reported by several earlier workers¹²⁻¹⁵, our results are significant as they hold strong implications for the conservation of vulnerable species in the sacred groves^{3,6,7}. The study underscores the importance of protecting the sacred groves from fragmentation if they have to serve as refugia for the vulnerable species.

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Seed-like structure in dinosaurian coprolite of Lameta Formation (Upper Cretaceous) at Pisdura, Maharashtra, India

Lameta Formation (Late Cretaceous) at Pisdura, Maharashtra has yielded a large number of dinosaurian coprolites (faecal mass) (Figure 1). These coprolites generally occur in different shapes and sizes. Depending on their external morphology, the coprolites have been categorized under four main types (A, B, Ba and C)¹. Type-A coprolites contain exclusively large amount of vegetal parts and their association with titanosaurid skeletal remains in the same bed suggests that the titanosaurs sauropods were the producers. Among the remaining categories not much is known about their producers, though some may belong to chelonians²⁻⁷. Plant-bearing coprolites are significant from the viewpoint of understanding feeding habits of these animals and their palaeoecology.

Records of megafloral remains in the coprolites are poorly known, except for a

few small plant structures of uncertain affinities and some softer parts of pteridophytic and gymnospermous origin^{6,8}. In this context the recovery of a large monocotyledonous seed-like structure embedded in the coprolite (Type-A) is noteworthy.

The coprolite measures about 6 cm long and 4.5 cm broad, greyish in colour, ovoid in shape containing two silicified seed-like structures (Figure 2b) measuring 2.0 cm in length and 1.5 cm in width. However, the complete seed partially embedded in the coprolite is slightly smaller, measures 0.9 cm in width (Figures 2a and 3a); light grey in colour; ovoid in shape (as seen in the sectional view; Figures 2b and 3b). It is enclosed in a thin endocarp (about 0.5 mm thick) (Figure 2a and d). Endosperm cells are compact and seem to be ruminated (Figure 2e). A degenerated embryo occupies

the lateral position in the seed (Figures 2b, c and 3b); cellular details of the embryo could not be resolved due to its poor preservation. The seed could not be generically assigned to an extant taxon due to the lack of more recognizable features. However, in extant palms, seeds can be distinguished on the basis of the position of the embryo; in arecoid, borassoid, cocosoid, and coryphoid groups, it is basal or apical; in the lepidocaryoid group it is ventral, while in the phoenicoid group the embryo is always lateral in position⁹⁻¹². Based on the shape, size, presence of single cotyledon and lateral position of the embryo, the seeds indicate close resemblance to the phoenicoid group of Arecaceae.

Records of Upper Cretaceous seeds/fruits referable to Arecaceae as *Palmo-carpon arecoides*, the fruits characterized