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# Biodiversity - 2014: Modern pollen assemblage of surface samples and its relationship to vegetation and climate in south-western Madhya Pradesh, India: A review

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## Abstract

Interpreting palaeovegetation and contemporary palaeoclimate from fossil pollen requires information on modern pollen-rain or deposition patterns of pollen/ spores in sediments of tropical deciduous forest (moist as well as dry types) in the area of investigation, which is achieved through the pollen analysis of surface samples, viz. surface soils/sediments, moss cushions (moss polsters), mud samples, spider web samples, leaf surface and bark that reflect modern vegetation and could be of immense help to refine and strengthen the interpretation of fossil pollen samples (Wright 1967; Flenley 1973; Moore & Webb 1978; Birks & Birks 1980; Liu & Lam 1985; Fall 1992). In the science of Quaternary palynology, this type of study has been given various names such as modern pollen-rain studies, modern pollen deposition patterns, modern pollenvegetation relationships, etc. In some advanced literature, the study has been given the name of Response Transfer Function as it serves as a modern analogue for the accurate explanation of the pollen sequences generated from the sedimentary beds in terms of past vegetation and climate in chronological order in the region during the Quaternary Period, especially the Holocene and/or Late Pleistocene epochs (Quamar & Chauhan 2012, 2013b; Chauhan & Quamar 2012a, 2012b).

So far as the relationship between the present-day set-up of vegetation and pollen assemblages is concerned, it is not straightforward. Owing to the differences in pollen production, dispersal and preservation (of taxa), some plant taxa are over-represented in pollen records whilst others are either under-represented or not represented at all (Tauber 1965; Prentice 1985; Prentice et al. 1987; Jackson & Lyford 1999; Sugita 2007) which depends on plant species and climatic conditions (Hicks 2001; Spieksma et al. 2003). Anemophilous species producing high quantities of pollen grains are over-represented, whereas species with zoophilous means of pollination produce lower numbers of pollen grains and are under-represented in pollen assemblages (Faegri & Iverson 1964).

In tropical regions, traditional pollen analysis was once upon a time thought to be impossible (Faegri 1966; Flenley 1973; Bush 1995) owing to the towering diversity of the tropical pollen flora (Flenley 1973), which was previously regarded as a stumbling block for palynologists to manage, in addition to the effect of pollen production and dispersal (on pollen analysis).

However, credit goes to Flenley (1973) who for the first time investigated the modern pollen rain in the tropics systematically. Many tropical pollen taxa are rarely or never encountered in samples, despite their pollen production and dispersal to sample sites, but with the aid of modern pollen spectra the modern pollen deposition pattern could be successfully related to the vegetation.

Like most palaeoecological research, the majority of work on modern pollen spectra has been carried out in temperate regions. However, the increasing interest in palaeoecological reconstruction of past tropical environments over the preceding two decades has led to more work on modern pollen spectra. A number of recent studies have been carried out in tropical areas of Africa (Vincens et al. 1997, 2000; El Ghazali & Moore 1998, Elenga et al. 2000), Australia (Kershaw & Stickland 1990; Kershaw & Bulman 1994; Crawley et al. 1994) and the mainland Neotropics (Grabant 1980; Bush 1991; Islebe & Hooghiemstra 1995; Rodgers & Horn 1996; Bush & Rivera 1998; Bush 2000; Bush et al. 2001, Marchant et al. 2001; Weng et al. 2004). In the Carribean islands, a few studies exist of sedimentary pollen profiles from lowland sites (Hodell et al. 1991; Higuera-Gundy et al. 1999), but modern pollen studies are wanting. Modern pollen rain studies were also conducted in Australia (Walker & Sun 2000), Southern Peru (Weng et al. 2004), Dominican Republic (Kennedy at al. 2005), southern Brazil (Behling & Negrelle 2006), tropical Andes (Rull 2006), northern Ecuador (Moscol Olivera et al. 2009), northeast Bolivia (Gosling et al. 2009), southern Ecuadorian Andes (Niemann et al. 2010), northern Belize (Bhattacharya et al. 2011), etc. and had generated data sets on the transfer functions regarding pollen representation to environmental parameters, as well as indicator taxa for particular ecosystems. Haselhorst et al. (2013) also conducted pollen rain studies in Panama and emphasized a better and more accurate reconstruction of palaeoenvironment and palaeoclimate in long-term pollen rain studies. However, in South Asia, especially India and Sri Lanka, Bonnefille et al. (1999), Anupama et al. (2000), Barboni and Bonnefille (2001) have conducted studies to address the modern pollen deposition pattern in tropical evergreen and deciduous forests. From the Indian context, several studies have also been conducted to address the problem, for example, from the foothills of the Himalaya (Sharma 1985; Gupta & Yadav 1992; Chauhan & Sharma 1993; Quamar and Srivastava, 2013; Ranhotra and Bhattacharayya, 2013), Kashmir (Vishnu-Mittre 1966; Vishnu-Mittre & Sharma 1966, Vishnu-Mittre & Robert 1971), Ladakh (Bhattacharyya 1989a), Himachal Pradesh (Sharma 1973; Bhattacharayya 1989b, 1989c; Bera & Gupta 1990), tropical deciduous scrub vegetation in Rajasthan desert (Singh et al. 1973), eastern Madhya Pradesh (Chauhan 1994, 2008; Quamar & Chauhan 2007), southwestern Madhya Pradesh (Quamar & Chauhan 2010, 2011a, 2011b, 2012, 2013a; Chauhan & Quamar 2012a, 2012b), Chhattisgarh (Quamar & Bera 2013a, 2013b, 2013c), Silent Valley, south India (Gupta & Bera 1996), Tamil Nadu (Bera & Gupta 1992), Uttar Pradesh (Sharma et al. 2007; Trivedi & Chauhan 2011)), northeast India (Gupta & Sharma 1985; Bera & Gupta 1992; Bera 2000; Basumatary & Bera 2007, 2010; Dixit & Bera 2011, 2012a, 2012b, 2013; Bera et al. 2012, 2013; Basumatary et al. 2013), South and Little Andaman Islands (Singh et al. 2010) and Odisha (Singh et al. 2011), etc. These studies have provided plausible assessments of the palaeovegetation and contemporary climatic scenarios from their respective regions during the Late Quaternary Period. The present communication, however, reviews the modern pollen rain studies carried out so far from southwestern Madhya Pradesh in India, with a view to refine and strengthen the interpretation of fossil pollen records, allowing the improved resolution of palaeoenvironmental changes (Prentice et al. 1991; Separ et al. 1994).

The present study reviews the pattern of modern pollen-rain carried out from south-western Madhya Pradesh, India, which largely revealed that Tectona grandis (teak), despite being an enormous pollen producer (7500 average number of absolute pollen/flower) (Bhattacharya et al., 1999) and the dominant forest constituent (80 to 95% of the total forest constituents), is recorded mostly in low frequencies, attributable to its low pollen dispersal efficiency as well as poor pollen preservation in the sediments. However, Madhuca indica (Mahua) and other dominant members of Sapotaceae (cf. Manilkara hexandra and Mimusops elangi) have always shown theirs' typical behaviour in the pollen spectra and representing in high frequencies, which is assigned to its local abundance around the provenance of the samples, coupled with high dispersal efficiency as well as good pollen preservation in the sediments. Meanwhile, the other usual and characteristic associates of teak (Tectona grandis) in the tropical deciduous forests, despite being the common elements of the forests, are under-represented, sporadically represented or not represented at all, which could be ascribed to theirs' low pollen productivity owing to entomogamy. Various factors that affect the deposition pattern of the diverse constituents of the tropical deciduous forests dominated by teak (Tectona grandis) have been discussed and suggestions were also given while interpreting the pollen sequences generated from the sedimentary beds in terms of past vegetation and climate in a chronological order in the region during the Late Quaternary Period.

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