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Pollen distribution and deposition in mangrove sediments of the Ranong Biosphere Reserve, Thailand

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ABSTRACT

Pollen analyses of surface and core sediments from the Ranong Biosphere Reserve, Ranong Province, Thailand, were carried out to determine spatial and quantitative compositional fidelities of the pollen record to achieve more accuracy in the reconstruction of past mangroves. The results reveal that many taphonomic biases from both biological and physical variables can lead to misinterpretation of the pollen records. Autochthonous pollen from true mangrove species were predominant in forest sediments, suggesting that mangrove sporomorphs are potential indicators of mangrove environments, while the frequent occurrence in low numbers of allochthonous and parautochthonous palynomorphs in mangrove sediments can reflect the regional plant communities. Close relationships between pollen from *Bruguiera*, *Rhizophora apiculata*, and *Sonneratia alba* and their vegetation were observed. The spatial reliability of *Avicennia alba*, *Aegiceras corniculatum*, *Ceriops tagal*, and *Xylocarpus* sp. pollen was low. The sediment cores show that the mangrove forest with its plant zonation was prograding towards the sea over time. The decline in *R. apiculata* pollen concentrations recovered in the upper part of all sediment cores reflects a decrease in the population of this plant taxon in the forest possibly caused by logging.

1. Introduction

Over decades attention has been paid to mangrove ecology and its relevance for climatic change, sea-level rise, and vegetation change. Since mangroves provide special ecological features, fossil pollen from mangrove sediments have been widely utilized in the interpretation of palaeovegetation and palaeoclimate (Grindrod, 1985; Ellison, 1989; Ellison and Stoddart, 1991; Woodroffe and Grindrod, 1991; Behling et al., 2001; Horton et al., 2005; Engelhart et al., 2007). In other words, fossil pollen from mangrove sediments are excellent indicators of a warm and humid climate and shoreline area as mangroves are only present in tropical and subtropical tidal regions and their pollen grains are dispersed locally (Grindrod, 1985).

Although, such a palynological record is a useful tool for the reconstruction of the palaeoenvironment (Grindrod, 1985; Behling et al., 2001; Yulianto et al., 2004, 2005; Cohen et al., 2005; Ellison, 2005, 2008; González et al., 2006), the qualitative and quantitative information of a pollen assemblage is biased due to uneven and incomplete pollen signals that are results of various taphonomic processes which can lead to a misinterpretation of the palynological data. An actuo-palaeobotanical study on contemporary pollen behaviour can help to determine the spatial resolution and quantitative compositional fidelity of the pollen fossil record to achieve more precision in the reconstructions of past mangroves. A number of actualistic studies indicate that the diversity, distribution, and abundance of mangrove sedimentary pollen are controlled by very complex taphonomic factors, including pollen production, pollination mechanism, pollen preservation, and composition of local vegetation as well as sedimentological and hydrological regimes (Wolanski et al., 1980; Ellison, 1989; Hofmann, 2002; Van Campo and Bengo, 2004; Moss et al., 2005; Mao et al., 2006; Li et al., 2008; Urrego et al., 2009, 2010; Phuphumirat et al., 2015, 2016).

Since the original composition may have been altered by such complex factors, a pollen assemblage occurring in sediment might not accurately reflect the standing or local vegetations growing in the area. In the Orinoco Delta, allochthonous and parautochthonous taxa were represented by higher percentages (in pollen taxa composition) than those of the autochthonous taxa (Hofmann, 2002). Another example of bias is shown by true mangrove plant species. High values of *Rhizophora* pollen can be found even in areas where no parent plants are growing due to their high pollen production and wind dispersion (Van Campo and Bengo, 2004; Engelhart et al., 2007; Urrego et al., 2010). In view of the above, mangrove vegetation types might not be differentiated accurately by the pollen record. Problems may arise

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when pollen spectra are used to determine mangrove dynamics over time in connection with sea-level changes, since the pollen record requires to provide zonation and successional data of past mangrove communities (Behling et al., 2001).

Much effort has been expended to establish the relationship between contemporary pollen and mangrove vegetation. Previous research shows that *Rhizophora* pollen have a close correlation to their parent plant stand even though this pollen taxon was found to be widespread throughout the forests as well as adjoining areas (Grindrod, 1985; Behling et al., 2001; Hofmann, 2002; Li et al., 2008; Urrego et al., 2010). A study of modern pollen distribution carried out at Missionary Bay, Australia, demonstrates that high proportions of *Rhizophora* pollen, with values over 90%, indicate *Rhizophora* vegetation, while lower values ranging from 44–59% represent neighbouring landward sites (Grindrod and Rhodes, 1984). Wijmstra (1969) and Bartlett and Barghoorn (1973) also used this phenomenon to interpret fossil mangrove pollen assemblages. However, in a more recent study, less than 52% of *R. stylosa* was recorded in its own plant community (Li et al., 2008). In the San Andres Island case (Colombian Caribbean), *Rhizophora* pollen were the most abundant species even in a vegetation predominated by *Avicennia* sp. (Urrego et al., 2010). The interpretations of *Avicennia*, *Laguncularia*, and *Sonneratia* pollen are equally controversial, as some studies considered them to be reliable proxies as a result of their highly localized representations (Mao et al., 2006; Urrego et al., 2010), while others did not (Grindrod, 1988; Behling et al., 2001; Van Campo and Bengo, 2004; Engelhart et al., 2007). Such differences in palynological data appear to be caused by a unique set of taphonomic factors existing at each study site. Therefore, great care must be taken when using such information in the reconstruction of past mangrove communities. More fundamental studies are required to gain an insight into pollen behaviour in response to various mangrove conditions.

In Thailand, there have been only a few studies focusing on using subfossil and fossil mangrove pollen as a bioindicator of palaeoenvironment (Somboon, 1990; Horton et al., 2005; Rugmai et al., 2008) and the possible bias that might be incorporated into the mangrove pollen record in this region as a result of dissemination patterns of mangrove pollen in the recent habitat. Therefore, the present study of pollen distribution and deposition was undertaken with the aim of precisely reconstructing past mangrove communities, particularly in peninsular Thailand, in terms of spatial and quantitative compositional reliabilities.

2. Study area

This study was carried out in mangroves situated in the Ranong Biosphere Reserve, Ranong Province, Thailand (Fig. 1). Due to its ecological, sociocultural, and educational significance, this mangrove forest was declared a World Biosphere Reserve in 1997 by the Thai government and UNESCO. The study sites are located in the core zone of the reserved area where no human activity is allowed and the primary forest is well-protected. The important characteristic of the Ranong mangroves is a complex network of interconnecting waterways

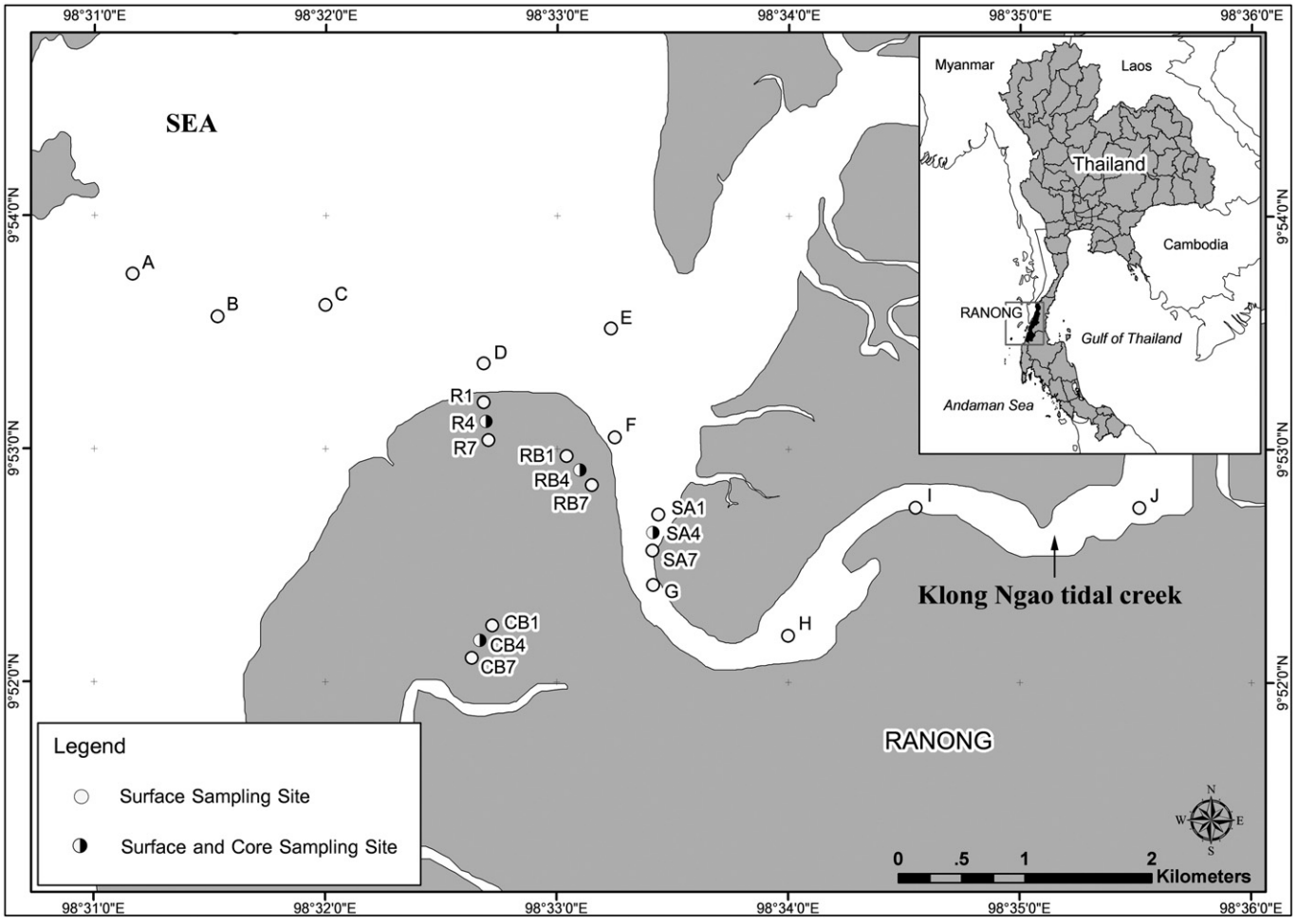

Fig. 1. The locations of the Ranong Biosphere Reserve and sampling sites (SA_{1-7}, R_{1-7}, RB_{1-7}, BC_{1-7}, A–D, E–J represent *Sonneratia alba–Avicennia alba* community, *Rhizophora apiculata* community, *R. apiculata–Bruguiera* sp. community, *Ceriops tagal–Bruguiera* sp. community, the marine environment, and the Klong Ngao tidal creek, respectively).