On the disappearance of palm genus *Nypa* from the west coast with its present status in the Indian subcontinent

Fossil pollen grains (Figure 1) of the palm genus *Nypa* described under *Spinizonocolpites* have been reported from the west coast of India in the Tertiary sediments of the Warkalli and Quilon formations in Kerala[1–4], and in the sediments of the Ratnagiri Beds in Maharashtra[5]. However, this monotypic genus represented by extant species *Nypa fruticans* (Thunberg) Wrumb., does not exist on the west coast of India[6–8]. This study is based upon observations made on the Ratnagiri Beds exposed along the west coast of Maharashtra (Figure 2).

N. fruticans is a gregariously growing monoecious palm (Figure 3 *a–c*), having dichotomously branched underground rhizomatous stem and a crown of leaves just above the surface. This genus is restricted to the littoral environment. Presently, it occurs between the latitudes of 25°N and 20°S[9,10]. It is distributed in Sri Lanka, the Ganges Delta, Andaman and Nicobar Islands, Myanmar, Malaysia and Philippines[8,11,12]. It also occurs in Indonesia, New Guinea, Solomon Island, Ryukyu Islands and Australia[12].

The fossil *Nypa* pollen type described under *Spinizonocolpites* has been reported from the Senonian of tropical West Africa and Borneo[10,13]. While in Europe the fossil *Nypa* fruits and pollen occur in rocks of Lower–Middle Eocene age[14], in Australia *Nypa* pollen have been recorded from Palaeocene to Middle Miocene age[15–18].

Mangroves thrive in the tidal zone influenced by highly specialized ecological conditions. As defined by Blasco[19], mangroves need saline water, saline soil poor in oxygen, the movement of water, daily submergence by tides, and average temperature of coldest month being above 16°C. *Nypa* in Sunderbans occurs along the border of mangroves, rather than close to the principle water course. It also needs humid soil permanently and removal of salt from the soil by freshwater[8]. Similarly, fruits germinate only in low-salinity soil conditions[20]. Further, *Nypa* does not occur on shores exposed to wave action and in hyper-saline conditions[12].

After its first appearance in the post-Turonian times in Sarawak[13] and the Senonian in West Africa[10], *Nypa* achieved an early pantropical distribution which was maintained during Palaeocene and Eocene[15]. Fossil record along the Tethys shores undoubtedly indicate a congenial warm period during Eocene for *Nypa* to flourish[15]. Decrease in temperature is the probable cause of extinction from the European region, while its disappearance at the end of the Eocene from the Caribbean and Nigeria has pos-

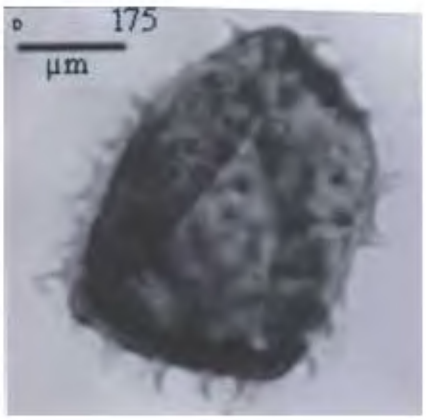

Figure 1. Fossil pollen of *Nypa fruticans* from Velas (bar, 175 µm).

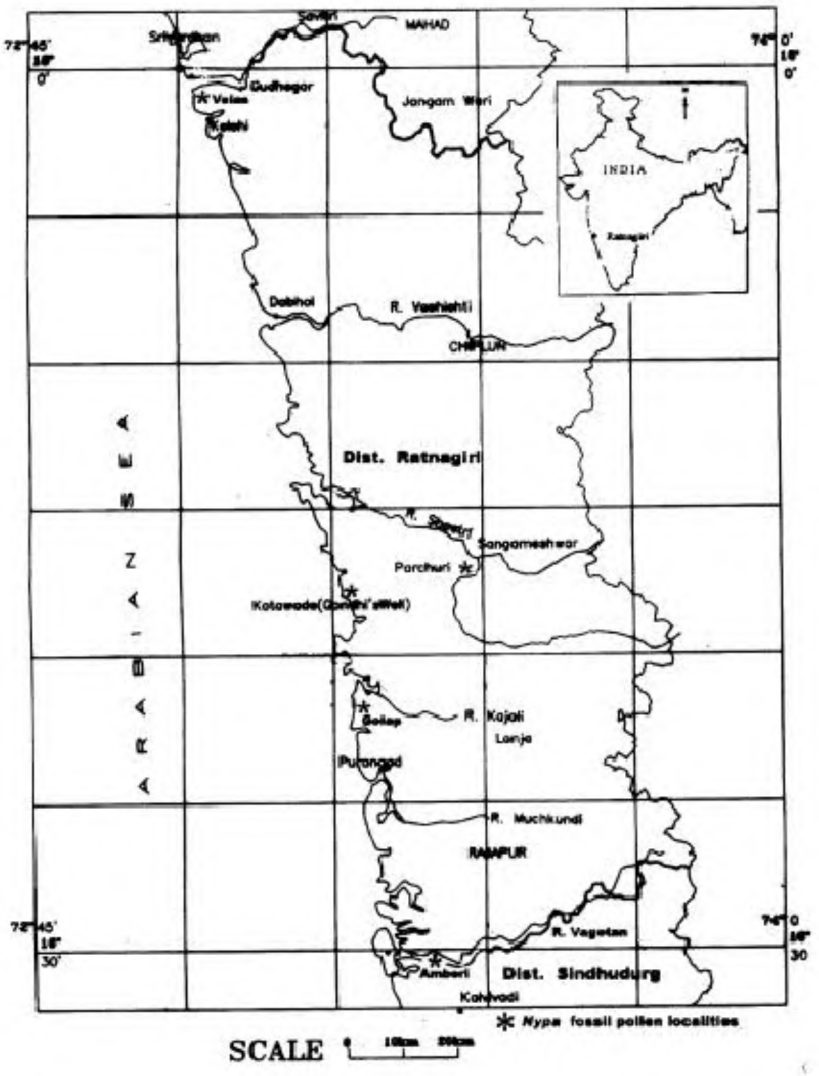

Figure 2. Location map.

Figure 3. (*a*) *Nypa fruticans* strand from Sri Lanka, (*b*) fruits (approx. 0.5X), and (*c*) inflorescence (approx. 0.5X). (courtesy of Dr Juliana Prosperi)

sibly been attributed to increase in aridity and the simultaneous setting in of a pronounced seasonal climate[15]. The extinction of *Nypa* from Australia has been attributed to the arid climate established during the plate movement and not due to decrease in temperature[9]. Further, *Nypa* became extinct from Venezuela at the Eo–Oligocene boundary due to a climatic change, as revealed by a widespread deposition of mottled shales indicating setting in of seasonal rainfall[15].

The geomorphology, environmental and finer ecological conditions that existed during the deposition of the Ratnagiri Beds were entirely different than at present. The Ratnagiri Beds mainly occur in patches exposed at a few places as escarpment sections or as dug-well sections, fringing the coastline from Velas in the north to Redi in the south. Also, there are deep inland occurrences as at Gudhegar, Parchuri, Jambhulphata, Amberi and Kalviwadi. A similar bed is exposed deep inland in Goa at the Sangod Mine[21]. Thus, there was an extensive development of mangrove ecosystem at the time of deposition of Ratnagiri Beds than at present. Geomorphologically, areas under mangrove should have been vast flood plains having freely meandering mature rivers with intervening, relatively elevated areas forming divides. There were a number of lagoons parallel to and in the immediate vicinity of the coast receiving sediments and supporting the mangrove vegetation, as conceived from the disposition of these beds. During the Late Pleistocene in western Maharashtra, rainfall was higher and more evenly distributed over the year than at present, as revealed from deep and intensive decomposition of basalts[22]. The high rainfall is also indicated by fossil pollen of the tropical rainforest families Dipterocarpaceae (*Retitricolpites dipterocapoides* Rao and Ramanujam) and Oleaceae (*Retitrescolpites splendens* Sah) belonging to the upland flora[23]. Influx of freshwater in the then existing lagoons and estuaries maintained ideal brackish-water conditions suitable for *Nypa*.

The Konkan coastal belt experienced neotectonic uplift during the Quaternary[24,25] by lifting up the sediments of Ratnagiri Beds to their plateau position from the estuarine and lagoonal depositional environments. Rate of elevation and erosion by rivers coped with each

other, thereby enabling river basins to maintain their base levels[21]. This resulted in confining highly meandering rivers in deeply entrenched valleys between newly raised lateritized plateaus. Thus, the present flat-top, extensive laterite plateaus overlying the fossiliferous clays delineate the areas that were then under estuarine environment, supporting mangrove vegetation. The neotectonic activity also resulted in developing high-raised cliffs bordering the narrow inter-tidal rocky platforms. This has resulted in destroying the lagoon system supporting the *Nypa* vegetation. Estuaries are now confined to deeply entrenched river valleys having restricted mud banks and a limited lateral spread for tidal waters across their meanders. This prompted the entry of marine water, having normal salinity, deep inland. The influx of freshwater in the estuaries is now restricted only to the monsoon months. Therefore, year-round perpetual brackish-water conditions of low salinity, ideal for *Nypa* do not exist along the west coast. During the dry period of eight months, the salinity in the estuaries is distinctly higher than during the rainy season. Further, the hypersaline condition during the dry season is pronounced in the mangrove areas due to the evaporation of stagnated spring high-tide waters in the upper reaches leading to accumulation of salts in the soil. Thus, the present west coast mangrove community supports species that can tolerate a rather wide salinity variation without *Nypa*.

Presently, the *Nypa* vegetation in Sundarban area of India is under great stress due to changes in geomorphic and ecological conditions[7]. The western and southwestern regions of this delta have been raised, shifting the main delta towards Bangladesh. This geomorphic evolution has an adverse effect on the *Nypa* vegetation due to lack of freshwater supply from the Ganges distributaries, that is essential to leach out excessive salt contents from the soil. A distinctive decrease in natural regeneration is most probably due to overall increase in salinity in the Indian part of Sundarbans (Chief Conservator of Forests (S) and Director, Sunderbans Biosphere Reserve, Govt. of West Bengal; pers. commun.).

1. Rao, K. P. and Ramanujam, C. G. K., *Curr. Sci.*, 1975, **44**, 730–732.
2. Rao, K. P. and Ramanujam, C. G. K., *Palaeobotanist*, 1976, **25**, 397–427.
3. Ramanujam, C. G. K. and Rao, K. P., *Geophytology*, 1977, **7**, 160–164.
4. Ramanujam, C. G. K., *J. Palaeontol. Soc. India*, 1987, **32**, 26–46.
5. Kulkarni, A. R. and Phadtare, N. R., *Phytomorphology*, 1983, **31**, 48–51.
6. Navalkar, B. S., *J. Bomb. Nat. Hist. Soc.*, 1951, **50**, 157–160.
7. Tralau, H. K., *Sven. Vetenska Acad. Handl.*, 1964, **10**, 5–29.
8. Blasco, F., *The Mangroves of India*, UNDP/UNESCO and French Institute, Pondicherry, 1975, 1st edn.
9. Muller, J., *Mem. Mus. Nat. Hist. Nat., Paris*, 1980, nos. 27, 211–218.
10. Muller, J., Proceedings of the IV International Palynological Conference, Lucknow (1976–77), 1979, vol. 1, pp. 568–578.
11. Banerjee, L. K., Sastry, A. R. K. and Nayar, M. P., *Mangroves in India*, Botanical Survey of India, Kolkata, 1989.
12. Tomlinson, P. B., *The Botany of Mangroves*, Cambridge University Press, Cambridge, 1994.
13. Muller, J., *Micropaleontology*, 1968, **14**, 1–37.
14. Ollivier-Pierre, M. F. and Caratini, C., 10e Reunion Annuelle des Sciences de la Terre, Bordeaux,1984.
15. Germeraad, J. H., Hopping, C. A. and Muller, J., *Rev. Palaeobot. Palynol.*, 1968, **6**, 189–338.
16. Hekel, H., *Geol. Surv. Queensland Publ. Palaeont. Pap.*, 1972, **30**, 1–31.
17. Martin, H. A., *Ann. Mo. Bot. Gard.*, 1982, **69**, 625–667.
18. Thanikaimoni, G., *Mangrove Palynology*, UNDP/UNESCO and French Institute, Pondicherry, 1987, vol. 24, pp. 1–100.
19. Blasco, F., *World Sci.*, 1992, **42**, 14–25.
20. Mahabale, T. S., *Palms of India*, Maharashtra Association for Cultivation of Science, Pune, 1982, monograph no. 3.
21. Badve, R. M., Sakurkar, C. V. and Vartak, A. V., *J. Geol. Soc. India*, 2002, **59**, 331–337.
22. Gupte, R. B. and Rajguru, S. N., *Bull. Volcanol.*, 1971, **35**, 686–695.
23. Saxena, R. K., Misra, N. K. and Khare, S., *Indian J. Earth Sci.*, 1992, **19**, 205–213.
24. Radhakrishna, B. P., *Curr. Sci.*, 1993, **64**, 787–793.
25. Powar, K. B., *Curr. Sci.*, 1993, **64**, 793–796.

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