Review of Palaeobotany and Palynology 186 (2012) 102–130

Contents lists available at SciVerse ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

Research paper

Non-pollen palynomorph studies in the Neotropics: The case of Venezuela

Encarni Montoya [a,*], Valentí Rull [a], Teresa Vegas-Vilarrúbia [b]

[a] Palynology and Paleoecology Lab, Botanic Institute of Barcelona (IBB-CSIC-ICUB), 08038 Barcelona, Spain
[b] Department of Ecology, Faculty of Biology, University of Barcelona, 08028 Barcelona, Spain

ARTICLE INFO

Article history:
Received 20 December 2011
Received in revised form 25 June 2012
Accepted 27 June 2012

Keywords:
Quaternary
modern analogues
Neotropics
non-pollen palynomorphs
palaeoecology
statistics

ABSTRACT

This paper summarises the NPP studies developed so far in a wide range of environments from Venezuelan lowlands, midlands and highlands, as an example of a growing discipline in a Neotropical area. The studies discussed include both modern analogues from surface sediments and Late Quaternary sequences combining pollen and spores with NPP analyses. Emphasis is placed on the utility of NPP as palaeoecological indicators both individually and collectively (NPP assemblages), as well as in combination with other proxies. The main advantages of using NPP instead of only pollen and spores are highlighted using case studies as examples. Among them, the occurrence of NPP in samples barren for pollen and spores, the independent indicator nature of NPP, and their capacity to reveal previously unnoticed environmental shifts (notably those related to local conditions), are emphasised. The main results obtained in all these analyses are discussed in the frame of several areas of the NPP study that are considered crucial (methods, taxonomy, indicator value and statistical treatment). Some ideas for future developments are proposed in each of these areas, and the need for closer collaboration among NPP specialists is strengthened, in a way towards unification and standardisation.

1. Introduction

The use of non-pollen palynomorphs (NPP) in Quaternary palaeoecology and archaeology has increased during the last decades and nowadays it is recognised as a powerful tool for past inference (van Geel, 2001). The advantages of considering NPP in palaeoecological studies rely on the independent and complementary nature of these remains in relation to pollen and pteridophyte spores (sporomorphs), as well as the additional information that they can provide by themselves on local environmental features. Combined sporomorph–NPP studies have increased the interpretative potential regarding past environmental conditions and historical trends of human disturbance, as useful tools for both palaeoecological reconstruction and landscape management (e.g., van Geel, 1978; van Geel et al., 2003, 2008).

The first detailed and comprehensive NPP studies were developed on temperate regions (van Geel, 1976, 1979; Kuhry, 1985; van Smeerdijk, 1989). In the Neotropics, the analysis of algal remains, mainly Zygnemataceae zygospores, from the Colombian Andes provided the first Quaternary NPP records, contributing to reconstruct the Late Pleistocene–Holocene climatic history (van Geel and van der Hammen, 1978). However, NPP Neotropical studies remain scarce and regional inferences are still lacking. A pioneering study on modern palynomorph sedimentation was carried out by Muller (1959) in the Orinoco delta, which included general references to fungi spores, dinoflagellate cysts and foraminiferal linings as a whole. The obtained results were proposed as a useful way to infer pre-Quaternary sedimentary environments in petroleum exploration, and have been the basis for the establishment of indices trying to quantitatively estimate the influence of either terrestrial or marine processes in sediment accumulation (Rull, 2000, 2002). However, precise identification of these NPP and ecological interpretations was not provided, avoiding possible links to the studies discussed below. To date, less than 30 studies are available for the Neotropics, including localities from Mexico (Almeida-Lenero et al., 2005), Colombia (van Geel and van der Hammen, 1978; Hooghiemstra, 1984; Kuhry, 1988; Grabandt, 1990; Pardo-Trujillo and Sánchez, 2009), Brazil (Medeanic et al., 2003; Ledru et al., 2006; Medeanic, 2006; Leonhardt and Lorscheitter, 2007; Roth and Lorscheitter, 2008; Scherer and Lorscheitter, 2008; Macedo et al., 2009; Lorente and Meyer, 2010; Medeanic and Bagatin Silva, 2010), and Venezuela (Rull and Vegas-Vilarrúbia, 1997, 1998, 1999, 2001; Rull et al., 2008; Montoya et al., 2010, 2011a, 2011b). As a result, the number of morphotypes known until now is still low and their ecological meaning insufficient for accurate palaeoecological reconstructions. Another handicap is the uncritical application of taxonomic and ecological knowledge obtained in temperate regions (Ledru et al., 2006; Rull et al., 2008).

Here, we present the studies developed to date in Venezuela based on NPP analysis, which include both modern sedimentation patterns and Lateglacial to Holocene records, as an example of a Neotropical region where this type of studies is growing and improving at present. So far, there are a total of six studies containing around 220 NPP morphotypes carried out in three different environments of the

* Corresponding author.
E-mail address: emontoya@ibb.csic.es (E. Montoya).

0034-6667/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.revpalbo.2012.06.008

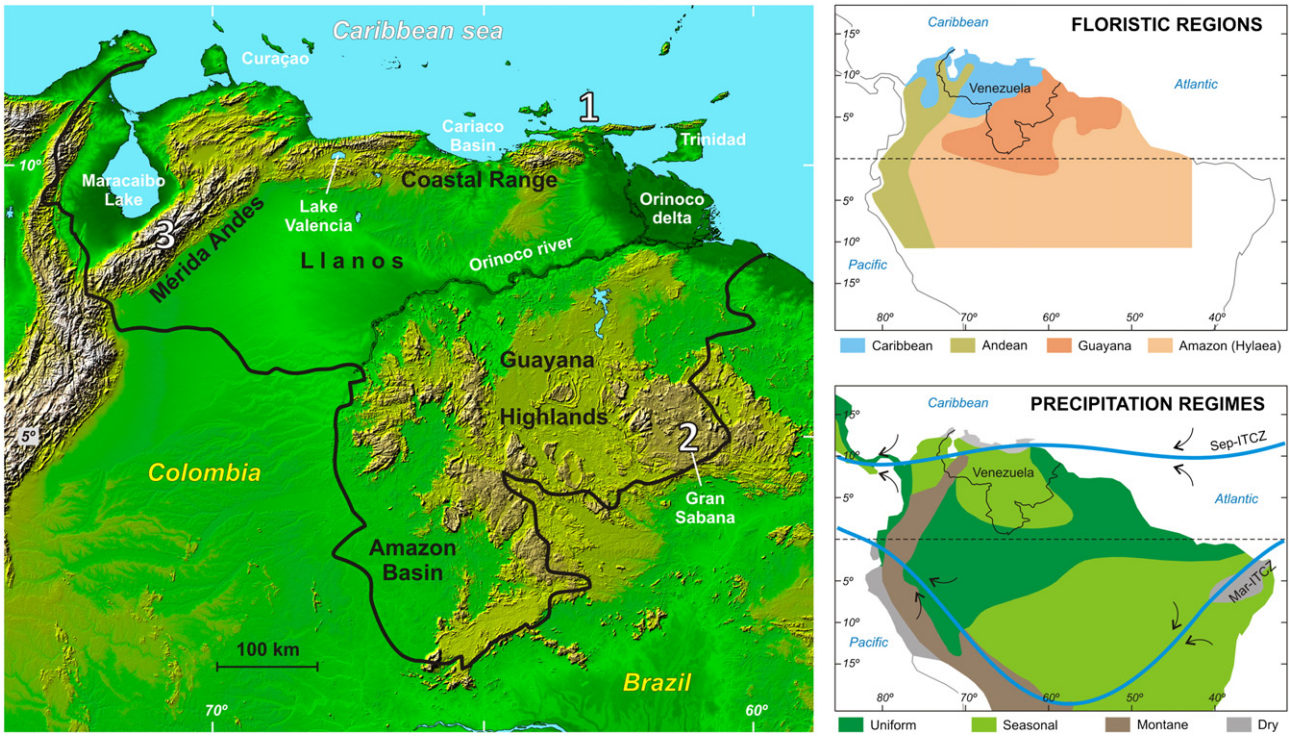

Fig. 1. Map of Venezuela, showing the main physiographic and floristic regions, the precipitation regimes, and the study areas mentioned in the text: 1 — Playa Medina (Paria Peninsula); 2 — The Gran Sabana; 3 — The Venezuelan Andes (base map courtesy of NASA/JPL-Clatech).
Modified from Rull et al. (2010).

country: the coastal lowlands, the Gran Sabana midlands and the Andean highlands (Fig. 1). This paper summarises the information obtained up to now that would be useful for palaeoecological interpretation, organised geographically, and highlights the utility of particular NPP morphotypes or associations by themselves or in relation to the sporomorphs. Each case study is depicted and briefly explained following the corresponding original paper, further general considerations and recommendations are given in the discussion. A comprehensive appendix (Appendix B) with most of the NPP forms found in the reported studies is also provided, with emphasis on unidentified forms, in order to facilitate identification and comparison with potential new findings.

2. The coastal lowlands

2.1. Playa Medina

Today, no permanent water currents cross the valley of Playa Medina (see Tables 1 and 2 for zone description); its drainage consists mainly in seasonal runoff towards a central shallow mangrove lagoon, completely covered by a monospecific mangrove stand of *Rhizophora mangle* (Rhizophoraceae) trees. The plant communities of Playa Medina are arranged in a typical coastal zone pattern, from the sea, crossing the lagoon to the internal slopes (Fig. 2; Table 2). The mangrove is the only community permanently flooded throughout the year, whereas the *Cocos* plantation is not flooded at all and the other communities are subjected to seasonal flooding. In this bay, a study of modern sporomorph and NPP sedimentation patterns was performed, in order to assess potential relationships between them and environmental features such as flooding, salinity, distance to sea and other micro-environmental features potentially useful for palaeoecological interpretation.

Sampling consisted of a transect of 19 surface samples along the sea-inland sequence quoted above (Fig. 2) (Rull and Vegas-Vilarrúbia, 1999). In general, pollen and spores were very scarce or absent in most samples, and the Playa Medina survey largely relied of NPP spatial patterns. A total of 75 NPP forms were encountered, of which 41 were fungal spores and 34 corresponded to unknown forms, likely remains of aquatic organisms (Appendix B: Plates I–VI). The spatial distribution of the remains found showed a notable heterogeneity, and a general

Table 1
General characterisation of the regions where the discussed studies are located. Climate values are referred to mean annual temperature and total annual precipitation respectively. ppt: parts per thousand.

Study site	Extent and elevation	Location	Coordinates	Climate	Main vegetation	Observations	References
Playa Medina	0.11 km^2 Sea level	Peninsula of Paria, NE Venezuela	10°42′–10°45′N 63°00′–62°52′ W	25.5 °C 818.1 mm	Mangrove and *Cocos* crops	Salinity of the mangrove lagoon: 1–4.5 ppt	Vegas Vilarrúbia (2000) Vegas-Vilarrúbia and Rull (2002)
Gran Sabana	18,000 km^2 750–1400 m	Between Orinoco and Amazon basins, SE Venezuela	4°36′–6°37′N 61°4′–74°2′W	18–22 °C 1600–2000 mm	Island of savanna within the Guayana rainforests	Occurrence of 5000–10,000 fires each year	Huber (1994a, 1994b, 1995b) Huber and Febres (2000)
Andes	2200 to 4700 m	Sierra de Santo Domingo, NW Venezuela	8°52′–8°46′N 70°52′–70°42′W	0–10 °C 700–900 mm	Montane forests and páramos	Decrease of 0.6 °C/100 m altitude	Monasterio (1980) Monasterio and Reyes (1980) Salgado-Labouriau (1979)