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MODERN POLLEN SIGNATURES OF THE AMAZON RIVER AND MAJOR TRIBUTARIES

THOMAS KENJI AKABANE

Orientador: Prof. Dr. Paulo Eduardo de Oliveira

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Dr. Paulo Eduardo de Oliveira

Dra. Marie-Pierre Winnie Ledru

Dr. Gregório Cardoso Tápias Ceccantini

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ABSTRACT

Akabane, T. K., 2019. Modern pollen signatures of the Amazon River and major tributaries [Master's Thesis], São Paulo, Instituto de Geociências, Universidade de São Paulo, 98p.

Part of the controversy of the ongoing debate about the paleoecology of the Amazon results from the scarcity of modern data to better elucidate the sources and processes controlling the fluvial pollen record. The Amazon River transports large amounts of pollen gathered from the several distinct environments present in the current drainage basin, but how each of these environments contribute to the pollen record remains poorly studied. In order to assess this problem, the palynological content of 36 riverbed sediment samples covering from the mouth of Içá River to the Amazon Estuary was analyzed with the support of x-ray fluorescence (XRF) analysis. The palynological analysis shows that vegetation of lowland floodplains is the main source of the pollen transported by the Amazonian rivers. Therefore, aspects of fluvial dynamics and geomorphology that control vegetation over the floodplains echo in the pollen record. The upper reaches of Amazon River and western whitewater tributaries are responsible for an abundant *Cecropia* contribution, reflecting an early-successional vegetation induced by high rates of lateral erosion by the rivers and a landscape dominated by scroll-bars. The middle and lower reaches exhibit a progressive increase in herbs mainly represented by Poaceae, Cyperaceae, Asteraceae, *Alternanthera, Amaranthus,* and *Acalypha,* related to an opening in the floodplain vegetation cover and a flatter topography occupied by lakes. Floodplain forests of whitewater rivers (*várzeas*) are characterized by *Iriartea*, *Mauritia*, *Ilex*, *Pseudobombax*, and *Luehea*, which, in consortium with high amounts of *Cecropia* or herbs, suggest early to late stages of succession typical of these environments. The *igapó* forests, on the margins of black- and clearwater rivers, are palynologically expressed by higher values of *Symmeria, Sapium, Piranhea, Pouteria, Amanoa, Myrtaceae,* and *Alchornea,* which indicate conditions of higher environmental stability and a mature forest. Contribution from the Andean Mountains and from the *cerrado* are clouded by the pollen production of the lowlands. Extensive anthropogenic disturbance may reflect in a local increase of *Cecropia,* though its influence on the overall Amazonian signature is not detected. DCA analysis shows a gradual transition of the pollen signature from the upper to the lower reaches of the Amazon River, suggesting that the hindmost pollen signature is mainly influenced by the production along the main stem. Published palynological data are contrasted and discussed in the light of the present findings.

Keywords: Palynology, Amazon Basin, modern analogue, riverbed sediments.

RESUMO

Akabane, T. K., 2019. Assinaturas palinológicas modernas do Rio Solimões-Amazonas e seus principais afluentes [Dissertação de Mestrado], São Paulo, Instituto de Geociências, Universidade de São Paulo, 98p.

Atualmente há uma grande quantidade de reconstruções paleoambientais, muitas vezes antagônicas, para tentar explicar a evolução ecológica da Amazônia. Parte da controvérsia decorre da escassez de dados modernos que permitam a comparação com o registro palinológico. O Rio Amazonas transporta grandes quantidades de pólen provenientes dos diversos ambientes que compõe a bacia de drenagem, no entanto o modo como cada um desses ambientes contribui para a formação do registro palinológico ainda é pouco conhecido. O presente estudo é baseado em análises palinológicas e de fluorescência de raios-X de 36 amostras de sedimentos coletados com draga ao longo de rios entre a foz do rio Içá e o estuário do Amazonas, incluindo os principais tributários. A assembleia palinológica encontrada mostra que a vegetação da várzea é a principal fonte do pólen transportado pelos rios. Portanto, os aspectos da geomorfologia e da dinâmica fluvial que impactam a vegetação sazonalmente inundada ecoam no registro palinológico. Os trechos superiores do Rio Solimões e tributários de águas brancas do oeste amazônico são responsáveis por uma expressiva contribuição de *Cecropia*, refletindo estágios iniciais de sucessão vegetal causados pelas altas taxas de erosão lateral, distúrbios causados pelos rios e a formação de barras. Os trechos médio e inferior exibem um aumento progressivo de pólen de ervas, representadas principalmente por Poaceae, Cyperaceae, Asteraceae, *Alternanthera*, *Amaranthus* e *Acalypha*, e relacionadas a uma abertura na cobertura vegetal da várzea e a uma topografia mais plana ocupada por lagos de várzea. As florestas de várzea são caracterizadas palinológicamente por *Iriartea*, *Mauritia*, *Ilex*, *Pseudobombax* e *Luehea*, e conjunto à grandes quantidades de *Cecropia* ou ervas, sugerem estágios iniciais e tardios de sucessão vegetal. As florestas de igapó margeiam rios de águas claras e pretas e são expressas por altos valores de *Symmeria*, *Sapium*, *Piranhea*, *Pouteria*, *Amanoa*, Myrtaceae e *Alchornea*, que indicam condições de maior estabilidade ambiental e uma floresta madura. A produção de pólen das terras baixas sobrepõe o sinal proveniente dos Andes e do *cerrado.* Distúrbios antropogênicos, como extensos desmatamentos, podem refletir em um aumento local de *Cecropia* que não se expressa na assinatura que chega à região do estuário. A análise de DCA mostra uma transição gradual da assinatura polínica ao longo dos rios Solimões e Amazonas, sugerindo que a assinatura palinológica é influenciada principalmente pela produção ao longo do canal principal. Por fim, dados palinológicos publicados são comparados e discutidos à luz do presente estudo.

Palavras-chave: Palinologia, Bacia Amazônica, análogo moderno, sedimentos fluviais.

1 INTRODUCTION

The Amazon Basin is the world's largest drainage basin and home to the most species-rich terrestrial ecosystem, in an area that encompasses almost half of the planet's remaining rainforests. The geological, climatic and biological evolution of this complex system is subject of an ongoing debate and a holistic approach is necessary for a better comprehension of the intricate Hyleaen history.

Palynology has an essential role in assessing past floristic shifts and as the vegetation tightly relates to the climate, hydrology and geomorphology, it works as a great paleoenvironmental tool (Salgado-Labouriau, 2007; Traverse, 2007). This is due to the fact that the pollen wall is made of an extremely stable biopolymer complex called sporopollenin that can last for hundreds of million years preserved in sediments (Brooks and Shaw, 1978; Schulte et al., 2008). This structure usually has striking features that allows us to trace back its parent-plant at family, genera and sometimes species level. Several palynological studies have been carried out to reconstruct the evolution of the Amazon Basin based on sediment cores collected in *terra firme* lakes (Colinvaux et al., 1996; Bush et al., 2004; Soares et al., 2017), floodplain lakes (Horbe et al., 2011; Sá et al., 2016), riverbanks (Latrubesse et al., 2010; Feitosa et al., 2015), shallow cores in tributaries (Behling et al., 2001; Irion et al., 2006), deep borehole (Hoorn, 1993), and the sedimentary deposits of the Amazon Fan (Haberle, 1997; Hoorn, 1997; Haberle and Maslin, 1999; Hoorn et al., 2017). Although it is possible to recognize floristic changes over the geological time, most of the studies on fluvial system deposits had their palynological interpretations carried out without the support of broader studies on the representativeness of the modern vegetation. The current knowledge of the modern fluvial palynological signatures along the main Amazon River is limited to a few suspended sediment samples analyzed by Haberle (1997).

The pollen content transported by the Amazon River derive from the riverbank vegetation, floating meadows, *terra firme,* extra-Amazonian regions, and reworked sediments of the floodplain. Sediments, as well as pollen grains gathered since the drainage headwaters, can be transported, deposited and reworked over thousands of kilometers before finally reach the ocean (Muller, 1959; Johnsson and Meade, 1990; Hoorn, 1997). Differently from endorheic lakes enclaved amid *terra firme* forests, that act

like a steady closed system, the fluvial systems are highly dynamic and influenced by a seasonal flooding regime, which restrict the edge vegetation to a lesser range of dominant *várzea*-adapted species (Kalliola et al., 1991; Wittmann et al., 2006). Frequent habitat disturbance by flooding, erosion of river margins and bars, and lateral channel shift, promotes an abundance of pioneer and early-successional vegetation along the Amazon River (Salo et al., 1986; Kalliola et al., 1991). The dynamics that affects the floristic aspects of floodplain reflect in the palynological record. According to Burn et al. (2010), the differentiation of riparian and *terra firme* pollen assemblages is driven mainly by the abundance of wind-pollinated taxa. The dominance of few anemophillous taxa, such as *Cecropia*, Poaceae, *Alchornea* and Moraceae contrasts with the rich diversity of entomophilous taxa that comprises the Amazon rainforest (Colinvaux et al., 1999).

The interpretation of the pollen records relies on a basic understanding of their sources, dispersal and depositional mechanisms (Bush and Rivera, 1998; Burn et al., 2010), which are still poorly known for the Amazon Basin fluvial system, although imperative for an accurate interpretation since the main sources of some pollen-types found in the record still remains obscure.

In this work, the modern palynological content of riverbed sediments collected along some of the main tributaries of the Brazilian Amazon Basin was analyzed to determine its sources in order to establish its relationship to different landscape variables. Multivariate analyses were applied to investigate gradients of variability and to distinguish the assemblage of the main tributaries; grouping pollen-types according to ecological aspects allows discriminating sources and making inferences about fluvial geomorphological features that influence the pollen record. Geochemical and grain size analyses were used to evaluate the source of the inorganic sediments as support for the palynological data. Sediment sources were distinguished on the basis of Al/K ratio, as mineralogical maturity index (Guyot et al., 2007), together with Fe/Ca and Fe/K ratios (Vital and Stattegger, 2000; Häggi et al., 2016). The Al/Si ratio, a grain size proxy (Bouchez et al., 2011), was used to evaluate sorting effect and pollen concentration on the sediments.

2 CONCLUSIONS

In this study, palynological analysis of riverbed sediments distributed along the Amazon Basin were used to investigate the relationship between the pollen source and the landscape. A significant conclusion of this study is that the palynogical signatures of the Amazon River and tributaries mainly correspond to the floodplain vegetation cover of the lowlands. Fluvial dynamics and the floodplain geomorphology play a important role in controlling the vegetation, which in turn reflects in the pollen load transported and deposited by rivers. The upper reaches of Amazon River, characterized by higher erosion, promotes constant succession that reflects in an abundance of *Cecropia*, whereas the lower reaches, a flatter floodplain covered by lakes, favor the dominance of herbs.

The hindmost palynological signature of the Amazon Basin, at the estuary, results from a major contribution of Solimões and Amazonas rivers. Negro River influence is important at the downstream stretches near the confluence and decreases eastwards, whereas the contribution from other tributaries are minor. Poaceae and other herbs better correlate with *várzea* grasslands and grow in importance at the stretches between Madeira and Tapajós rivers. Xingu and Tapajós Rivers do not cause a detectable change in the Amazon River palynological signature, thus environmental changes in Central-Brazil region are unlikely to cause major oscillations in the palynological record of the Amazon fan deposits. The dissonance between the modern pollen records and the regional surrounding vegetation raises another evidence of the dubious meaning of Poaceae as a reliable indicator of either open or dry landscapes in the *terra firme* context. Low values of Poaceae and montane taxa in the Western Amazon reveals that the Andean grasslands does not contribute with relevant amounts of pollen. Extensive anthropogenic disturbance does not cause an expressive change in grass signal, as indicated by Xingu River. These findings can help in a more accurate interpretation of the palynological record of fluvial deposits and the Amazon fan.

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