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Recent Palynology in Caxiuanã, Pará, Brazil

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Abstract

A survey on palynological studies realized in the National Forest of Caxiuanã, state of Pará, Brazil, is given. These studies comprise two main issues. Firstly, the morphology of actual pollen grains and spores was described and illustrated. Secondly, pollen grain and spore deposition in a savannah-like area and in "terra-preta-de-índio" (Indian black soil) of the National Forest of Caxiuanã were analyzed. Joining this knowledge, local, regional and environmental changes and oscillation could be related to recent vegetational fluctuations and to human/Indian activities realized in the region of Caxiuanã.

Keywords

Pollen Morphology, Actuopalynology, Quaternary, Amazon

Subject Areas: **Biogeography, Food Science & Technology**

1. Introduction

The National Forest of Caxiuanã, located in the state of Pará, Brazil, encompasses the research institution "Estação Científica Ferreira Penna (ECFPn)", as part of the Museu Paraense Emílio Goeldi, Belém, Pará. This area, designed mainly for scientific research, covers part of the municipalities of Melgaço and Portel, located at the intersection of the coordinates 1˚60'S and 51˚30'W (**Figure 1**). Anapu is the main river in this region, maintaining a south/north direction. Beside the rivers, several bays were originated during neotectonic events in the Quaternary period. The most important is the bay of Caxiuanã, 8 km wide and 40 km long [1].

A humid tropical forest dominates all over this area, comprising the non flooded forest of "terra firme", the floodplain forest or forest of "várzea", savannah-like and grassland-like areas and aquatic environments as "igapós", "igarapés", lakes and bays. High biodiversity provides broad forms of investigation.

Pollen grain and spore analysis started in the Caxiuanã region for more than fifteen years ago [2] [3]. These studies intended first to understand a grassland-like vegetation in conformity with the adjacent floodplain and

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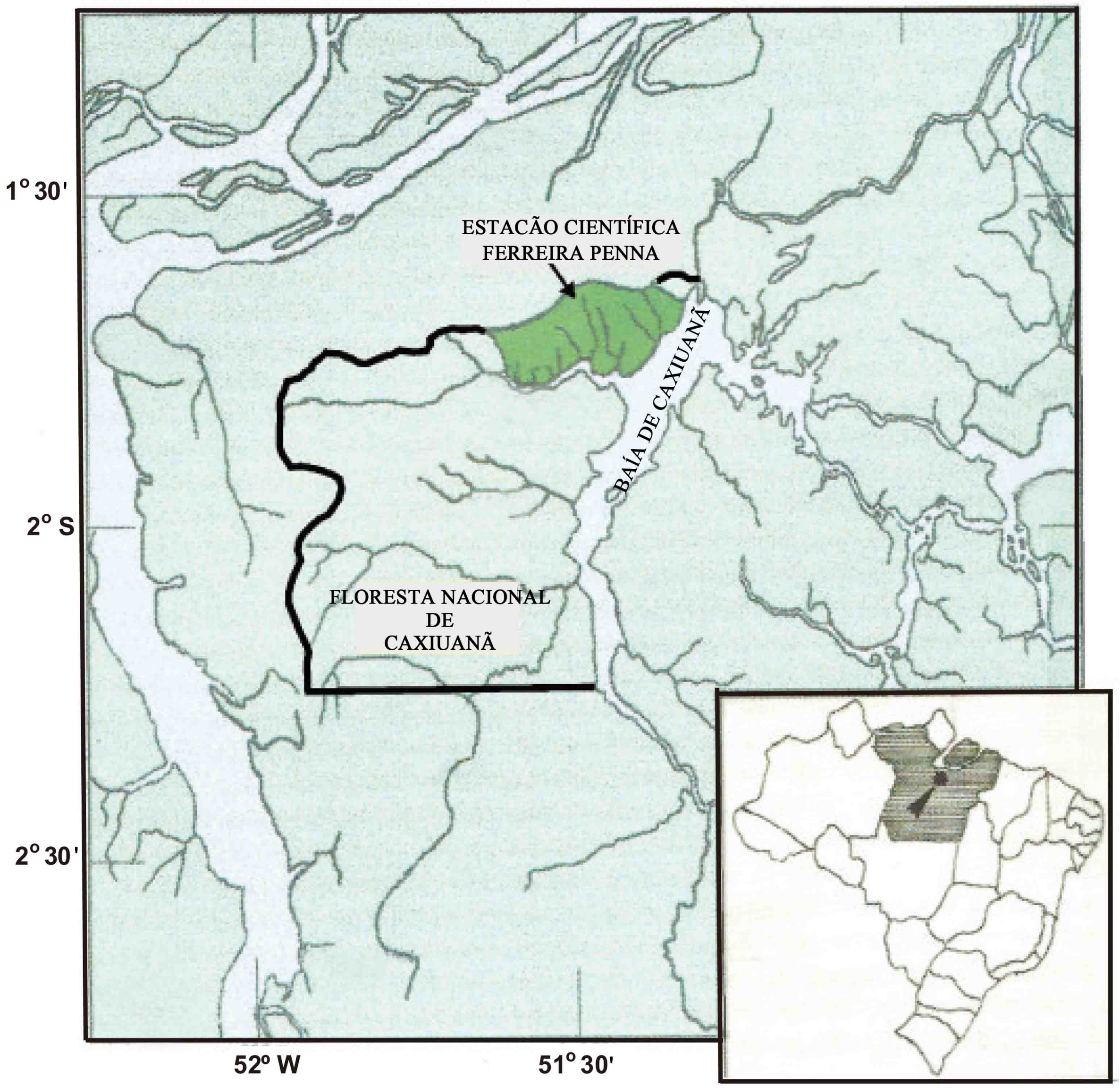

Figure 1. State of Pará, the National Forest of Caxiuanã and the ECFPn (adapted from [1], p. 28).

"terra firme" forest. Second, early human activity was to be investigated. Third, in order to attend these two questions, the pollen grain morphology of savannah-like and forest plant species inform the behavior of the actual pollen dispersion and precipitation in soils and into aqueous sediments in relation with strong raining and the bay water level oscillation.

2. Pollen Grain Morphology

Morphology of pollen grains, spores of Bryophyta and Lycopodiophyta/Pteridophyta, of plants occurring in the ECFPn area in Caxiuanã was formerly presented in several papers [2] [4]-[7] (**Figure 2** and **Figure 3**), and is the basic knowledge to start the investigation of the questions detailed above.

Bryophyta sporoderms of species of the Bryidae subfamily were analyzed using light and scanning electron microscopy the chemical treatment the spores were submitted was successful, what means that fragile spores may be recovered in sediments, like pollen grains and fern spores. A single layer of exine is covered by a perine which confers the granular ornamentation of the eight species analyzed. All of them are small sized and show a leptoma (apertural area). Detailed morphological characteristics of *Callicostella pallida*, *Fissidens elegans*, *F.*

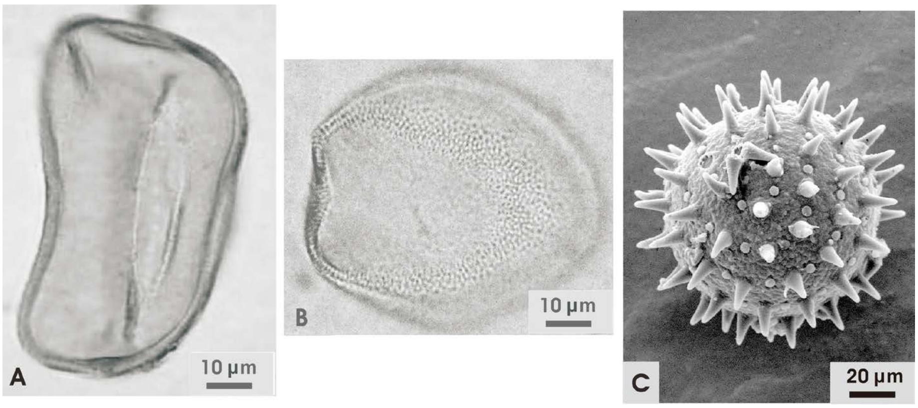

Figure 2. Pollen grains obtained from *in situ* collected taxa: (A)-*Eichornia azurea* (Pontederiaceae) [7]. (B)-*Xyris caroliniana* (Xyridaceae) [7]. (C)-*Malachra radiata* (Malvaceae) (scanning electron image) [6].

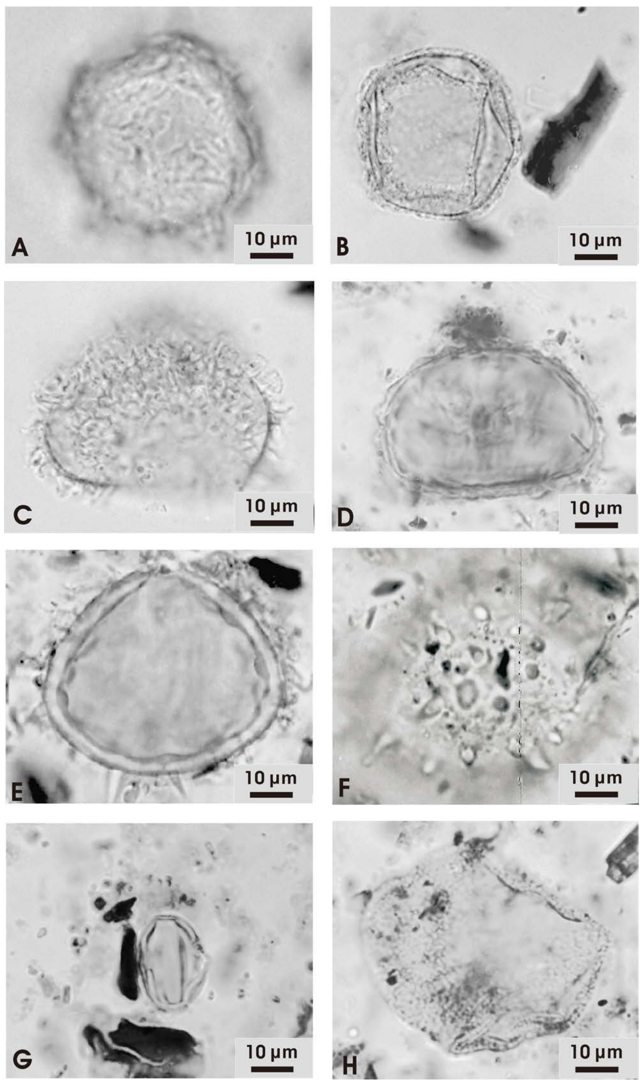

Figure 3. Pollen grains and spores of some plant species occurring in the savannah-like area and recovered from the soil [5]: (A) and (B) spores of Bryophyta; (C) and (D) spores of Pteridophyta, *Selaginella* and *Dryopteris* respectively; (E) and (F) optical section and surface feature of *Mauritia flexuosa* (Arecaceae); (G) pollen grain of *Clidemia hirta* (Melastomataceae) and carbon particles; (H) pollen grain of *Annona paludosa* (Annonaceae).

prionodes, *Leucomium strumosum*, *Octoblepharum albidum*, *Sematophyllum subsimplex* and *Trichosteleum guianae* were presented.

Lycodiophyta/Pteridophyta trilete spores [7] present a variable form and genus specific ornamentation. The ambitus may be triangular (*Lycopodiella cernua*, *Polypodium* sp.) or circular (*Azolla filiculoides*, *Marsilea* sp., *Salvinia auriculata*, *Salvinia* sp.).

Pollen grain morphology of 16 species of 11 genera of aquatic monocotiledoneous macrophytes shows variable characteristics [7]. Tetrads occur in *Juncus* sp. only. Atreme pollen grains belong to *Ischnosiphon polyphyllus* (Maranthaceae) and spirotreme pollen grains to *Tonina fluviatilis* (Eriocaulaceae). 1-porate pollen grains are frequent as in *Lemna valdiviana* (Araceae), *Cyperus odoratus* (Cyperaceae) and *Luziola spruceana* (Poaceae). 1-colpate pollen grains belong to *Pistia stratiotes* (Araceae), *Commelina diffusa* (Commelinaceae), *Tacca parkeri* (Dioscoreaceae), *Mayaca fluviatilis* and *M. sellowiana* (Mayacaceae). 2-colpate pollen grains occur in *Eichornia azurea* (**Figure 2**), *E. diversifolia*, *Pontederia cordata*, *P. rotundifolia* (Pontederiaceae) and X*yris caroliniana* (Xyridaceae) (**Figure 2**).

Aquatic dicotiledoneous macrophyte species present a wide range of morphological characteristics. Species of ten genera were studied [6]. Pollen grain size, form, apertures and ornamentation vary strongly. Large tetrads belong to *Victoria amazonica* (Nymphaceae), 1-colpate pollen grains to *Nymphaea* and *Cabomba*, 2-colporate, 4-pseudocolpates to *Dianthera* (Acanthaceae), 3-colporates to *Nymphoides indica* (Gentianaceae), *Conobea scoparioides* (Scrophulariaeae), *Hydrocotyle prolifera* (Apiaceae) and *Sesbania exasperata* (Leguminosae-Papilionoideae/Fabaceae-Faboideae), 10-colporates to *Utricularia breviscapa* (Lentibulariaceae), 14-colporates to *U. oligosperma* and *U. cf. poconensis*, 17-colporates to *U. longifolia*, 3-porates to *Ludwigia* (Onagraceae) and pantoporates to *Malachra radiata* (Malvaceae) (**Figure 2**).

The pollen grain morphology of 13 species (11 families) occurring in a savannoid vegetation in the ECFPn-Caxiuanã was described [2]. The most common grass was *Panicum rudgei* (Gramineae/Poaceae) with 1-porate pollen grains. *Annona paludosa* (Annonaceae) presents tetrads. *Helicteres pentandra* (Sterculiaceae), *Mucuna altissima* (Leguminosae-Papilionoideae/Fabaceae-Faboideae), *Sauvagesia erecta* (Ochnaceae) and *Vismia guianensis* (Guttiferae/Clusiaceae) present 3-colporate pollen grains. Polyades of *Stryphnodendron pulcherrimum* (Leguminosae-Mimosoideae/Fabaceae-Mimosoideae) comprise 16 pollen grains. Pollen grains of *Hyptis recurvata* (Labiatae/Lamiaceae) are 8-colpate, that of *Clitoria falcata* (Leguminosae-Papilionoideae/Fabaceae-Faboideae) 6(-7)-colpates, of *Clidemia* and *C. novemnervia* (Melastomataceae) 3-colporates, 3-pseudocolpates and that of *Psidium guineense* (Myrtaceae) and *Sabicea amazonensis* (Rubiaceae) are 3(-4)-colporates.

Herbarium specimens and pollen slides were deposited in the herbarium of the Museum Paraense Emílio Goeldi. Spore and pollen grain illustrations were presented in the respective papers mentioned.

3. Pollen grain and Spore Deposition

Grassland-like, savannah-like areas, wherein the tropical forest is absent, challenge opinions about its origin and evolution. One of these areas is located next the west side border of the Caxiuanã bay [1] and was chosen for palynological investigation (**Figure 4**).

Six samples were obtained along a SW-NE transect, starting from the bay side bordered with *Mauritia flexuosa* into the "terra firme" forest, crossing the savannah-like area. A seventh sample was collected east side in a grassland (savannah) area. Each sample was composed of 25 nearby located soil subsamples.

The association of pollen grains and spores (palynomorphs) recovered from these sediments (**Figure 5**) could be characterized and illustrated [5].

The greatest richness of pollen grains occurred in the more distant sample of the bay border (transect, sample Forest 2). Araliaceae, Asteraceae, Dioscoreaceae, *Casearia*, *Cassia*, *Helicteres pentandra*, *Hyptis*, *Stryphnodendron*, *Symplocos* and *Zanthoxylum* pollen types were exclusive in this place [8], been primarily from trees and shrubs. The grassland's exclusive pollen types were *Alternanthera*, Asclepiadaceae, Bignoniaceae, Cyperaceae, Malvaceae and *Tapirira*, mainly herbs. Pollen grains of aquatic species of *Utricularia* were detected in sediments of the two forest samples only. Spores of Lycopodiophyta/Pteridophyta were not frequent. Nearly all transect samples showed a high number of spores of Bryophyta and fungi, and burned plant fragments (size below 50 micra), mainly stomata. Spores of Algae disappeared in the forest sediments.

Palynomorphs preservation was no good. Sporoderm oxidation was assigned to air exposition, mechanical damage to the transport of palynomorphs in sandy water of the bay. Another aspect was the low number of pollen

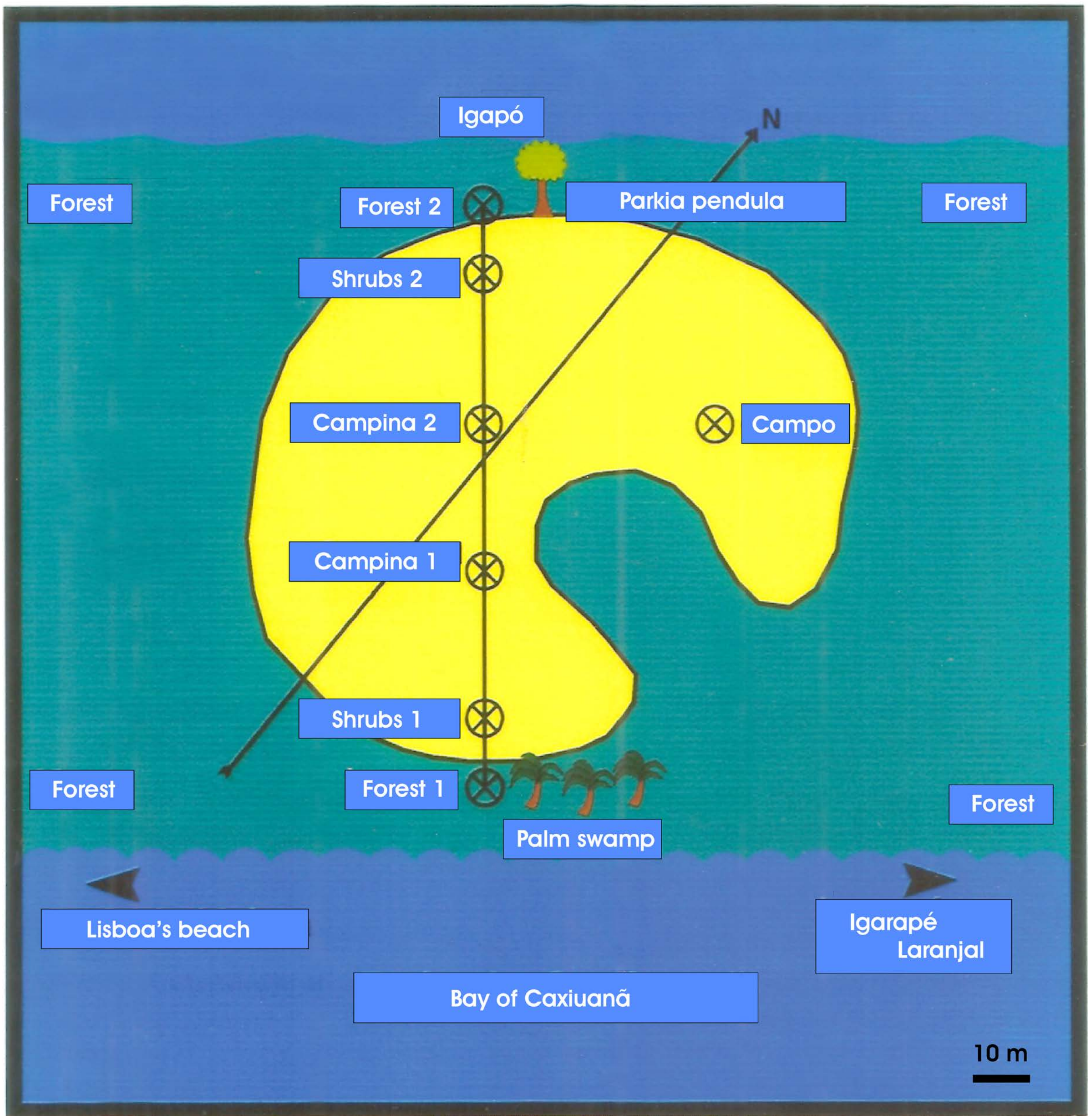

Figure 4. Scheme of the savannah-like area, located west side of the bay of Caxiuanã. Six places on the transect line of soil samples collected and one isolated grassland soil sample are marked. Bar = 10 m. (adapted from [8]).

grains when compared with that of spores of Bryophyta and fungi and the total organic material [3] [8]. Small sized pollen grains were more frequent than medium or large sized ones. Dominant entomophily of tropical trees and shrubs can explain this behavior.

Analyzing pollen grains, spores of fungi and algae and carbonized plant material recovered from soil samples of the savannah-like area in the tropical forest of Caxiuanã, palynomorphs were less frequent next to the Caxiuanã bay border than inside the more distant forest. All data obtained show the strong influence of tropical raining, land flooding and the bay water level oscillation.

Burned plant fragments as dust and stomata occurred frequently in sediments of the open grassland area. Probably, successive burning by humans modified the soil permeability to the point that forest installation was not successful just at today [9].

Pollen morphology and pollen spectra are a very useful tool in analyzing environmental fluctuations in the

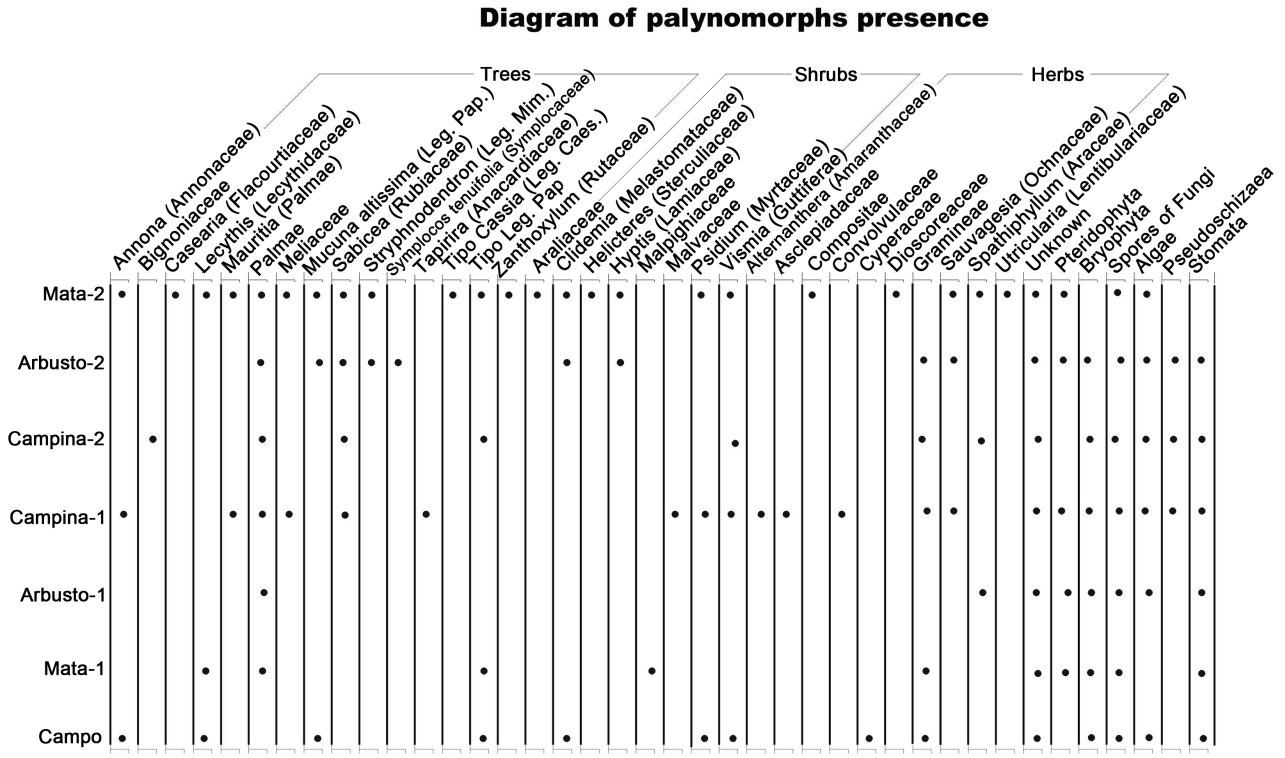

Figure 5. Diagram of palynomorphs presence along the transect line and in the grassland patch. (Arbustos = Shrubs, Campina = Savanna-like, Campo = Savannah, Mata = Forest) (adapted from [8]). The diagram was obtained using the TILIA and CONISS programs [5] [11].

tropics. The best resolution is achieved by the highest number of plant species or taxa identified and its association. Palynotaxonomy helps to get a fine resolution in limited areas. Morphological studies of pollen and spores of plant species that devise the types of vegetation occurring in the ECFPn-Caxiuanã area, was the starting point for interpretation of the local dynamic environment. Actual pollen precipitation could be recognized by Barth *et al.* [8] in recent soils. Elder river sediments were analyzed by Behling and Costa [10] starting by 8000 ^{14}C yr B.P. (years before present).

Next to the ECFPn-Caxiuanã flona, Barros *et al.* [9] investigated black soil sediments ("terra-preta-de-índio") in an area formerly occupied by Indians, recovering pollen grains and spores. Strong human activities could be detected.

4. Conclusion

In conclusion, the knowledge of actual pollen and spore morphology allows to study local and regional environmental changes as an answer to vegetational fluctuations in dependence of climatic oscillations. Secondly, it allows to investigate Indian activities inside the Amazon region, when Caxiuanã was inhabited by much more Indians than today before European colonization.

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References

[1] Lisboa, P.L.B. (Ed.) (1997) Caxiuanã. Museu Paraense Emílio Goeldi, Pará, 446 p.

[2] Carreira, L.M.M., Barth, O.M., Barata, F.C.A. and Kalume, M.A. de A. (1997) Caracterização polínica atual da vegetação savanóide. (Current Pollen Characterization of the Savannah-Like Vegetation.) In: Lisboa, P.L.B., Ed.,

Caxiuanã, Museu Paraense Emílio Goeldi, Pará, 319-328.

[3] Barth, O.M., Barros, M.A., Santos, D.S. and Carreira L.M.M. (1997) Análise palinológica de amostras de superfície de solo de área de vegetação savanóide. (Palynological Analysis of Surface Soil Samples of a Savannah-Like Area.) In: Lisboa, P.L.B., Ed., *Caxiuanã*, Museu Paraense Emílio Goeldi, Pará, 329-331.

[4] Luizi-Ponzo, A.P., Barth, O.M. and Lisboa, R.C.L. (1997) Estudos palinológicos em Briófitas. (Palynological Studies in Bryophyta.) In: Lisboa, P.L.B., Ed., *Caxiuanã*, Museu Paraense Emílio Goeldi, Pará, 305-318.

[5] Barth, OM. (2001) Palynomorphs from a Recent Soil Covered with a Savanna-Like Vegetation in Caxiuanã, Pará, Brazilian Amazon. *Pesquisas em Geociências*, **28**, 285-306.

[6] Carreira, L.M.M., Barth, O.M., Lucas, F.C.A., Gurgel, E.S.C. and Santos, S.F. (2009) Caracterização morfopolínica de macrófitas aquáticas da flora de Caxiuanã—I. Dicotiledôneas. (Morphopollinic Characterization of Acquatic Macrophytes of the Caxiuanã flora—I Dicotyledoneae.) In: Lisboa, P.L.B., Ed., *Caxiuanã*: *Desafios para a conservação de uma floresta na Amazônia*. (*Caxiuanã*: *Challenges for a Conservation of a Forest in the Amazon*.) Editora do Museu Paraense Emílio Goeldi, Belém, Pará, 331-346.

[7] Carreira, L.M.M., Lucas, F.C.A., Barth, O.M., Gama, T.S.S., Dias, A.C.R., Gurgel, E.S.C. and Germano, C.M. (2013) Caracterização morfopolínica de macrófitas aquáticas da Flona Caxiuanã II Monocotiledôneas e Licófitas. (Morphopollinic characterization of acquatic macrophytes of the Caxiuanã Flona—I Monocotyledoneae and Lycopodiophyta.) In: Lisboa, P.L.B., Ed., *Caxiuanã*: *Paraíso conservado* (*Caxiuanã*: *Preserved Paradise*.) Museu Paraense Emilio Goeldi, Belém, Pará, 311-322.

[8] Barth, O.M., Toledo, M.B., Barros, M.A. and Carreira, L.M.M. (2002) Espectro palinológico do solo de uma vegetação savanóide. (Palynological Spectrum of Soil of a Savannah-Like Vegetation.) In: Lisboa, P.L.B., Ed., *Caxiuanã*: *Populações Tradicionais, Meio Físico e Diversidade Biológica*. (*Caxiuanã*: *Traditional Populations, Physical Environment and Biological Diversity*.) Museu Paraense Emílio Goeldi, Belém, Pará , Graphite Editores, 473-480.

[9] Barros, M.A., Barreto, C.F., Barth, O.M. and Kern, D. (2000) Terra preta arqueológica do sítio Manduquinha, Caxiuanã, Pará, Brasil: Uma análise palinológica. (Archaeological Black Soil in the Manduquinha Site, Caxiuanã, Pará, Brazil: A Palynological Analysis.) *Revista Universidade Guarulhos, Geociências,* **V** (especial volume), 150-155.

[10] Behling, H. and Costa, M.L. (2000) Holocene Environmental Changes from rio Curuá Record in the Caxiuanã Basin (Eastern Amazon Basin). *Quaternary Research*, **53**, 369-377. http://dx.doi.org/10.1006/qres.1999.2117

[11] Grimm, E.C. (1987) Coniss: A Fortran 77 Program for Stratigraphically Constrained Cluster Analysis by the Method of the Incremental Sum of Squares. *Computer and Geosciences*, **13**, 13-35. http://dx.doi.org/10.1016/0098-3004(87)90022-7