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Species Richness, Density and Distribution of Palms in an Eastern Amazonian Seasonally Flooded Forest

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ABSTRACT

Species richness, density and distribution of a palm community found in a seasonal swamp forest in the Eastern Amazon Basin (Serra dos Carajás, Pará, Brazil) is here reported. In the hectare sampled, eight species in eight genera were found. Of the 3,975 palm individuals in the study area, 60% belong to only one species, *Orbignya phalerata,* which occurs in greater density in the less humid areas, while *Socratea exorrhiza* and *Geonoma baculifera* prefer the more humid sites. Results are discussed in terms of soils, water and light.

RESÚMEN

La riqueza de especies, densidad y distribución de palmeras en una comunidad localizada en un bosque periodicamente inundable de la Amazonía oriental son discutidas aqui. En la hectárea estudiada, 8 especies en 8 genéros fueron encontradas. De las 3,975 palmeras encontradas en el área de estudio, 60% pertenece a una sola especie, *Orbignya phalerata,* que ocurre en mayor densidad en las áreas menos húmedas, mientras que *Socratea exorrhiza* y *Geonoma baculifera* prefieren los sítios más humedos. Los resultados se discuten en relación a suelos, agua y lúz.

In spite of the particular difficulties involved in palm research, not only in regard to taxonomy but also to the study of population biology and reproductive systems, palms are receiving increasing attention, due in part to the economic potential and to the special position they occupy within tropical ecosystems.

Among the papers on palms focusing on population biology those of Bouillenne (1930) with *Mauritia,* Oldeman (1969) with *Euterpe oleracea,* Granville (1977) with several species, Anderson (1983) with *Orbignya phalerata* and Piedade (1985) with *Astrocaryum jauari,* can be cited. Communities have been studied by Kahn and Castro (1985), who worked with species occurrence in relation to water; Kahn (1986*a*, 1987), and Kahn et al. (1988) who have looked into species richness and density, and Kahn (1986b) who studied life forms, size, and density in relation to forest structure and dynamics.

This paper presents data on species richness and distribution in terms of light and water gradients for a palm community in a seasonal swamp forest of the eastern Amazon basin.

Methods

Research was carried out in a seasonal swamp forest at the margins of Igarapé Azul (06°00′S, 50°42′W), in the area worked by the Companhia Vale do Rio Doce, Projeto Carajás, Marabá Municipality, state of Pará, Brazil (Fig. 1). The study area was ca. 1.5 km upstream from the intersection of the creek with the road between DOCEGEO'S "N1" and "Alpha" camps.

Soils are predominately very acid yellow-red latosols, with very low concentrations of exchangeable ions, sandy at the stream margins, gradually turning more clayish with increasing distance from the stream.

Five 20 × 100 m transects, perpendicular to the stream, were laid out, with each transect being divided into ten 10 × 20 m plots. Using a Blume-Leiss hypsometer, the height above the water surface level of the stream was taken at the center of each plot.

All palm individuals, separated into either adults, juveniles, or seedlings, were counted in each plot. For caespitose species, each stem was considered as a separate individual. Adults were considered as those individuals that were already reproductively active; juveniles as those that had well formed trunks and crowns but that were not yet active in reproduction, and seedlings as those individuals that lacked well-formed trunks and crowns and presented first leaves.

Quantitative data are presented based on horizontal distance from the stream bed, as well as in terms of height above the surface of the creek. In the latter case, the 50 study plots were grouped according to 1 meter class intervals: 0–1 m (6 plots), 1–2 m (16 plots), 2–3 m (15 plots), 3–4 m (8 plots) and 4–5 m (5 plots).

Density per hectare was calculated for each size class, per species, within each class interval along the water gradient.

Voucher specimens of all palm species were collected and deposited at the CENARGEN (CEN) Herbarium in Brasília.

1. Localization of the study area.

Results

In the hectare studied, eight species of palms, belonging in eight different genera were found: *Astrocaryum munbaca* Martius, *Euterpe oleracea* Martius, *Geonoma baculifera* (Poit.) Kunth, *Socratea exorrhiza* (Martius) Wendland, *Maximiliana maripa* (Corrêa de Serra) Drude, *Oenocarpus distichus* Martius, *Orbignya phalerata* Martius and an unidentified species of *Bactris*.

Table 1 presents the number of individuals per species in each size class found in the study area. *Orbignya phalerata* was the most abundant species overall (60.2%), while *Geonoma baculifera* had the highest number of adults. *Oenocarpus distichus* and *Maximiliana maripa* were the least abundant, with no seedlings found in the study area. Seedlings of all species accounted for 70.3% of all individuals.

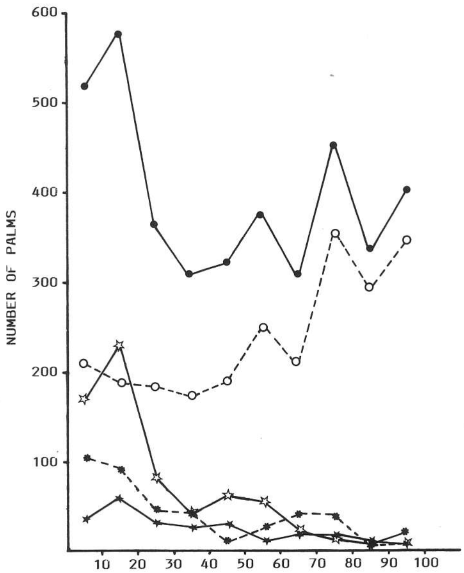
Densities of palms with increasing distance from the stream are shown in Figure 2. Although no clear cut patterns can be discerned, highest densities were found in the first 20 m, due mainly to the high number of individuals of *Geonoma baculifera*, *Euterpe oleracea* and, to a lesser extent, *Socratea exorrhiza*, which were more abundant closer to the water. In contrast, the density of *Orbignya phalerata* increased with distance, due to greater number of seedlings. For *Astrocaryum munbaca* density remained practically constant. The low number of individuals of *Bactris* sp., *Maximiliana maripa* and *Oenocarpus distichus* makes it impossible to infer distribution patterns.

Overall densities for the species in question, on a vertical gradient from the surface of the stream, can be seen in Figure 3. Highest densities were found closest to the water level: for example, the 5,092 individuals/ha in the 0–1 m class decreased

Table 1. Palm densities on 1 hectare of seasonally flooded forest at Igarapé Azul, Serra dos Carajás, Pará, Brazil.

Species	Number of Individuals			
	Seedlings	Juveniles	Adults	Total (%)
Orbignya phalerata	2,177	199	17	2,393 (60.2)
Geonoma baculifera	84	396	222	702 (17.7)
Euterpe oleracea	334	9	58	401 (10.1)
Socratea exorrhiza	117	105	15	237 (6.0)
Astrocaryum munbaca	78	80	38	196 (4.9)
Bactris sp.	4	36	1	41 (1.0)
Oenocarpus distichus	—	—	3	3 (—)
Maximiliana maripa	—	2	—	2 (—)
Total	2,794	827	354	3,975

to 3,610/ha at 4–5 m. The species responsible for this trend were chiefly *Geonoma baculifera, Socratea exorrhiza* and, to a much lesser extent, *Euterpe oleracea.* As before, *Astrocaryum munbaca* maintained relatively constant densities. *Orbignya phalerata* presented higher densities on higher ground.

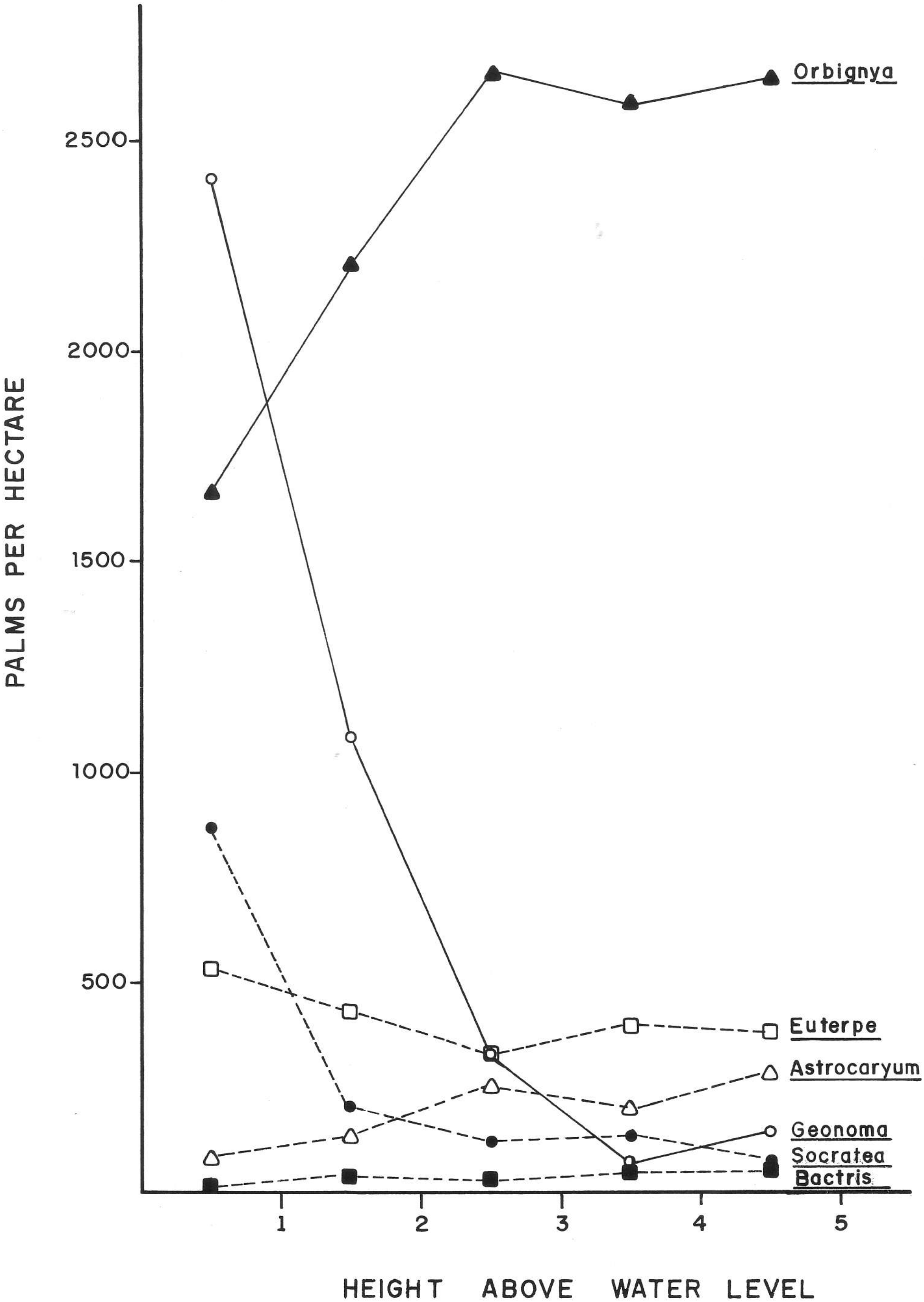


2. Number of palms at different distances from the stream. O, *Orbignya phalerata*; ☆, *Geonoma baculifera*; * *Euterpe oleracea*; ★, *Socratea exorrhiza*; ●, Total for all species, including *Astrocaryum munbaca* and *Bactris* sp.

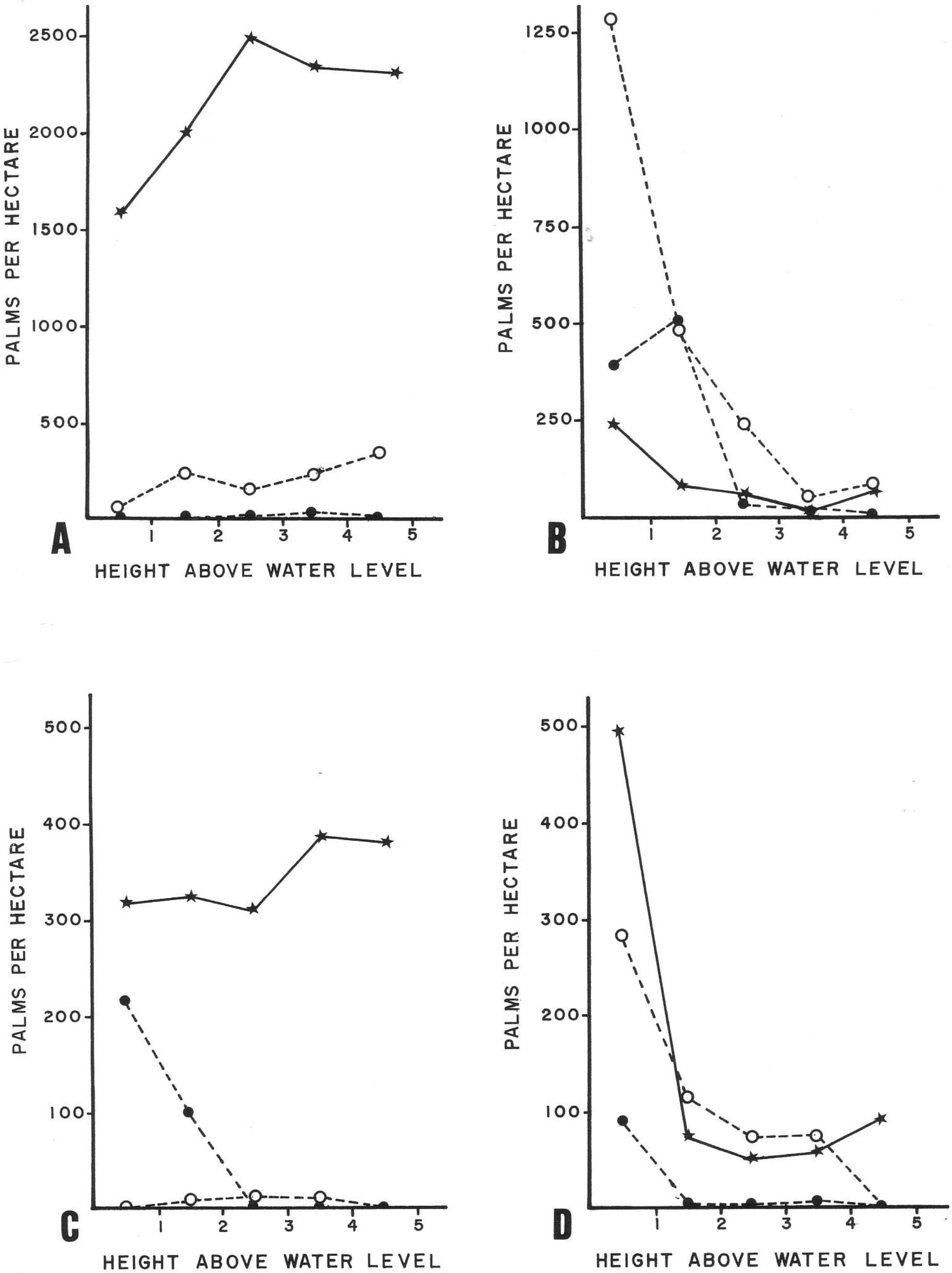
Figure 4 shows densities, along a vertical gradient, for the three size classes (adults, juveniles, and seedlings) of *Orbignya phalerata, Geonoma baculifera, Euterpe oleracea* and *Socratea exorrhiza.* In *Orbignya phalerata,* densities of juveniles and adults increased towards higher ground, with adults maintaining similar densities throughout. Both *Geonoma baculifera* and *Socratea exorrhiza* showed distinct preference for more humid soils for all three size classes, with the number of individuals decreasing drastically on higher soils. *Euterpe oleracea* behaved like these two with respect to juveniles and adults, while maintaining high densities of seedlings throughout the topographic gradient.

Discussion

Table 2 shows a comparison of species diversity and density for palms under varying soils and water conditions for several studies throughout the Amazon basin. In spite of the differences in size of the study areas involved, data are sufficient to support Kahn et al.'s (1988) claim that western Amazonia is richer in species than the eastern portion of the Basin, supporting the idea that western Amazonia is one of the richest regions in palm species diversity in the Americas (Lleras et al. 1983). Thus, it can be seen that, compared with other



3. Vertical distribution (densities) for the six most important species.



4. Vertical distribution (densities) for the three size classes. ●, Adults; ○, Juveniles; ★, Seedlings. A. *Orbignya phalerata*; B. *Geonoma baculifera*; C. *Euterpe oleracea*; D. *Socratea exorrhiza.*

Table 2. Comparison of species richness and density of palms under different soil-water conditions for several studies throughout the Amazon Basin.

Region	Soil Water	Size Classes Included	Number of Genera	Number of Species	Density/ha	Area Sampled (ha)	Source
Eastern Amazonia							
Tocantins Valley, Pará—Brazil	Diverse	All	9	21	2,224	10.56	Kahn (1986*a*)
Carajás, Pará—Brazil	Poorly drained	All	8	8	3,975	1.00	This paper
Central Amazonia							
Manaus, Amazonas—Brazil	Well drained	All	7	9	620–800	0.45	Takeuchi (1960)
Manaus, EEST/INPA, Amazonas—Brazil	Well drained	All	11	26	3,231	0.72	Kahn & Castro (1985)
Manaus, EEST/INPA, Amazonas—Brazil	Poorly drained	All	10	10	4,666	0.24	Kahn & Castro (1985)
Manaus, EEST/INPA, Amazonas—Brazil	Waterlogged	All	7	7	10.512	0.24	Kahn & Castro (1985)
Western Amazonia							
Jenaro Herrera, Rio Ucayali, Peru	Well drained	≥1, 2 m	—	—	3.500	0.7	Marmillod (1982)
Jenaro Herrera, Rio Ucayali, Peru	Well drained	All	16	29	9.860	0.71	Kahn et al. (1988)

areas, the area studied for this paper is relatively poor in species diversity.

Another salient point is that palm density is highest in the more humid (water logged or poorly drained) soils, decreasing toward higher ground. According to Kahn and Castro (1985), this may, in fact, not be related to water, but to light intensity in the understory, which is higher in seasonally flooded than in terra firme forests. Kahn et al. (1988) maintain that the higher density of palms in western Amazonia compared with the central and eastern portions of the Basin is due to the higher number of caespitose (multi-stemmed) species in the understory in the former, noting also that this also reflected a difference in dominant life forms for the western forests.

The higher density of palms found near the stream, in the present study, is due mainly to the large number of individuals of the caespitose species *Geonoma baculifera* and *Euterpe oleracea* and, to a lesser degree, the single-stemmed *Socratea exorrhiza*. Kahn (1986*a*) has already shown the preference of *Geonoma baculifera* for hydromorphic soils, which explains the abundance of this species near the stream margins, while Granville (1978) has shown that caespitose species are among the dominant life forms in seasonally flooded forests.

Euterpe oleracea occurs in highest density close to the creek. The species, which fits into Tomlinson's growth model (basal ramification with formation of clumps—Hallé et al. 1978) is under high selective pressure, as can be seen by the high number of seedlings throughout the study area (Fig. 4C). Small clearings are insufficient to accommodate the species, as lateral axes are shaded by the main axis and surrounding vegetation. Thus, adults predominantly grow in humid soils with high light intensity.

Species that have Corner's growth model (single-stemmed with lateral inflorescences, Hallé et al. (1978), such as *Orbignya phalerata* and *Socratea exorrhiza*, generally have high light requirements for shoot growth. This restricts growing conditions to two basic situations (Kahn and Castro 1985): a) open clearings in the interior of the forest, or b) sparse forest with well illuminated understory. Anderson (1983) and Anderson and May (1985) note that although shade favors seed germination in *Orbignya phalerata*, it inhibits stem growth. Thus, the low number of seedlings of this species near the water is probably due to high light intensity and humidity. However, occurrence of adults in similar densities throughout suggests that the limiting factor is not water but light.

Socratea exorrhiza seems to be unable to survive in the shade (but see Hogan 1986), while requiring high humidity. This limits its distribution to the fairly humid, well-lighted margins of watercourses, and gaps in the wetter portions of the forest.

In general, the present paper shows that two major environmental factors play key roles in determining palm density and distribution: humidity and light intensity.

Acknowledgments

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LETTERS

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Dear Natalie:

I have recently returned from Costa Rica where I had the privilege of revisiting the Robert and Catherine Wilson Botanical Garden (formerly known as the Las Cruces Tropical Botanical Garden) in the mountains around San Vito de Java, Costa Rica. As you recall, this is where I lived in 1974–75 after completing my undergraduate education. It was truly a joy to return to a place that I once called home.

While living in Las Cruces I had the chance to work intensively on the palm collection, consisting of native species as well as introduce plants that Bob Wilson's many friends and associates would send him from all over the world. It was remarkable see these specimens, now flowering and fruiting, like so many children having grown up over the last 15 years. I understand that the Garden suffered somewhat during the late 1970's and early 1980's but signs of this past struggle are certainly not evident today. Much of this is due to the hard work of the current Director, Dr. Luis Diego Gomez and his staff. The dream of Bob and Catherine Wilson, to build a botanical garden in a tropical paradise, still lives on and flourishes today.

I have had the chance to visit many of the other gardens in the Neotropics. It is always sad to observe the state of things at so many of these places. While many are founded by a person with a vision, after the founding person is gone the local economy is not always able to support a collection of ornamental and useful plants. There are simply too many more pressing priorities in the developing world.

The Wilson Garden is especially important because it is one of the few gardens focusing on palms, both native and exotic.

(*Continued on p. 190*)