Progress Report of Research Conducted on the Alpha Helix Amazon Expedition

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Light Environments in Rain Forests on the Lower Amazon

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The Instituto de Pequirias e Experimentacao Agropecuarias do Norte (IPEAN) at Belém has developed a number of floristic reserves in divergent types of rain forest. These areas have been under intensive interdisciplinary study for only a short period of time but they seem unique among natural study areas in the world for the detail and character of the botanical mapping and mensuration which are under way. With the enthusiastic cooperation of Vicente Moraes, and the generous assistance of J. M. Pires of IPEAN's Secao Botanica, we were able to work in these reserves between September 15 and 27.

Site description: (In part from: J. M. Pires, 1966 APEG Report).

I. Mocambo forest. A 5.67 ha "terra firme" forest in which 215 species of 136 genera and 52 families have been identified. There are 3260 individual trees with diameters greater than 10 cm. *Esehweilera corrugate*, *Tetragastris trifoliolate*, *E. odora*, *Protium guacayanum*, *P. paraense*, *Vochysia guianensis* and *Vonacapona americana* are the most frequent species; among families, Leguminoseae is represented by the greatest number of species. The forest is quadrated on a 10 m grid; the principal study area was in quadrats 6-15 through 6-20 for which detailed profile drawings were available. Canopy heights range from 35 to over 40 m. This is a climax forest with near constant biomass.

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II. Igapó transect. To the north of the Mocambo terra firme, a 960 m x 10 m transect has been surveyed in igapó (defined here as forest flooded during much of the year as forest flooded during much of the year by rain water without deposition of sediments). The vegetation is much more open, shorter and with fewer species; 476 plants have diameters greater than 10 cm. Most frequent are Caraipa grandiflora (28% of individuals), Taralea oppositifolia, Tapirina guianensis, Virola surinamensis, Bombax aquaticum, and Pterocarpus amazonicum. As at one of the Rio Negro sites, the largest tree is a strangler fig, in this case Ficus pulchella. Integrators were set in an 80 m transect from 1-7 to 1-15.

III. Capeoira - Black. This is a regrowth forest of unknown age in succession. The physiogomy (short and open) is more nearly like the igapó than like the terra firme; 283 species of 83 families (richest in Leguminoseae, Graminae, Rubiaceae, Flacourtiaceae, and Passifloraceae) have been identified.

IV. Varzea. The varzea forest, a tidal flood plain, about 50% subject to periodic flooding with sediment-laden Guama River water, is now being quadrated in the same fashion as the Mocambo. In one 3.8 ha study area (Pires and Kaury, Bol. Tec. do Inst. Agron. Norte 36: 3-44, 1959), 107 species were found with strong dominance of Enterpe oleracea, Astrocaryum murumuru, Pithecolobium latifolium, Carapa quianensis, Quararibea quianensis, Hura cripitans and Hevea braziliensis. The physiogomy was intermediate in height and denseness to the terra firme and igapó forests. Integrators were displayed in quadrants 183-12 to 183-21.

V. Young rubber plantation. A 14-year old planting of Hevea braziliensis with open canopy constituted the last site. The original planting was on a 7 x 2.5 m grid but thinning to 7 x 7.5 m (300 trees/ha) was 50% complete. Canopy height, 8 to 10 m. A dense grass and brush understory of less than 1 m height existed.

Results and discussion: Ozalid-paper light integrators were displayed within each of the experimental sites. In the following table, daily irradiances relative to fully exposed sites are given. By assumming the extinction was uniform throughout the canopies and had the same value as determined by Odum in Puero Rico (K = 0.18), estimates of leaf area index were obtained (from our work with crop plant communities, it is apparent that this approach gives only a first approximation of canopy structure). Several interesting points are evident from a preliminary analysis of these data.

Table 1. Light penetration and derived leaf area indices (6 to 10 observations).

		Daily mean light penetration - %		Mean leaf area index from top of canopy to	
Site		Ground	1.5 m	Ground	1.5 m
I	Mocambo terra firme a)	1.5	-	10.2	-
	b)[1/]	1.1	1.8	10.8	9.8
II	Igapó transect	3.7	-	8.0	-
III	Capoeira - Black	1.8	6.5	9.7	6.6
IV	Varzea	1.0	2.2	11.3	9.1
V	Rubber plantation	-	16.8	-	4.3

[1/] Data from profiles of Table 2 as measured at a later date.

Table 2. Light profiles in Mocambo terra firme.

Height above ground meters	Daily mean light penetration - %	Mean leaf area index from top of canopy
0	1.1	10.8
2	1.8	9.8
5	1.7	9.8
10	4.4	7.5
15	6.0	6.8
20	8.1	6.1
25	15.1	4.5

The varzea, terra firme and capoeira forests were similar to the whitewater igapó (varzea) of the Rio Negro in light interception while the igapó and rubber canopies were similar to the Negro's blackwater vegetation. In the Mocambo terra firme, about 85% of the incident light was intercepted by the trees emergent above 25 m, or about the same as with the rubber plantation. Thus, the rich understory of the terra firme forest exists in a poverty light environment. Pires and Moraes report that growth rates for understody trees are extremely slow - many of the trees near 10 cm in diameter may be more than 30 years old.

In comparing light interceptions at ground level and at 1.5 m height (or at 2.0 m in the terra firme), it is apparent that the capoeira had the greatest density of foliage near the ground (herbs, tree seedlings, etc.), that the varzea was somewhat more open and that the terra firme had the least vegetation in that layer. The dense canopy of the terra firme forest was an effective barrier to the growth of young tree seedlings. There was an abundance of very young (up to one-year old) seedlings but very few older seedlings indicating heavy attrition when cotyledon reserves are exhausted. Pires' curves on size distribution of various species in the Mocambo are particularly striking on this point. We were impressed by the heavy fruit production shown by many species. While many of the seed are parasitized and fail to germinate even in suitable conditions, seedlings were relatively abundant. It appears that one of the most significant events in these forests is the collapse of a large emergent tree. Whether the tree falls or decays in a standing position, a large hole in the canopy is usually opened and the increased light releases the suppressed seedlings and saplings. Species survival obviously depends on sufficient reproductive capacity to ensure the presence of seedlings whenever and wherever release occurs.

One of our principal objectives had been to survey the leaf display habits of the emergent trees. As a hypothesis, it seemed that in such evergreen forests, where competition is predominantly inter- rather than intra-specific, that displays for maximum interception per unit leaf area would be advantageous. Thus, one might expect the emergents to tend towards spreading crowns, horizontal leaf display and a minimum of mutual shading. Vertical photographs from the ground within the forests using a telephoto lens proved unsatisfactory for studying leaf display because of the strong back lighting. A limited survey was done with oblique camera angles from along the edges of clearings. A more practical approach would be to climb representative species and obtain sample branches for direct measurement of leaf area and display - this was not practical during the present trip. However, our observations were sufficient to find that leaf clumping was more intense in the emergent crowns and that the displayed angles were much more vertical than anticipated. It would be important to assess the implications of such observations in competition, and to learn whether the high proportion of diffuse to direct sunlight contributed to selection in leaf display habit.

Vertical views through a fish-eye lens were photographed at each site, as on the Rio Negro, for analysis of the size and angular distribution of gaps in the foliage canopy.

A second major objective, remote surveys of tropical vegetations by aerial photography, was thwarted by the lack of an airplane on the Rio Negro. A plane finally was obtained at Belém for one photography run, and ektachrome, infrared ektachome, and panchromatic views with appropriate filters were obtained from 550 feet for each of the listed sites. The infrared film is the key material but it has a narrow exposure range and exposures usually must be adjusted to each type of vegetation. Two exposures were used and a calibration series was obtained on a varzea type vegetation. Vegetative surveys from aerial photographs have tremendous potential in the analyses of tropical forests. Some work has been done in Nigeria and Costa Rico but in each case species identification was not possible because ground mapping had not been done. The IPEAN forests at Belém are completely mapped and thus offer unique opportunities for calibrating the behavior of different species with various films and lighting conditions. Hopefully, our films will provide a good introduction to such work.

The Amazon forests offer a plethora of important and exciting opportunities in ecophysiology. On the present expedition, we were poorly prepared with time or equipment for detailed studies of carbon dioxide exchange by leaves, biomass dynamics, leaf display or canopy photosynthesis.

The IPEAN forests and associated laboratories provide an excellent place for such work, and Pires and Moraes have some studies under way on these subjects. We judge that IPEAN would welcome cooperative studies and consideration should be given to promoting more detailed and longer term investigations.