Arthropod Distribution in a Tropical Floodplain Ecosystem

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Introduction:

•A latitudinal diversity gradient has long been observed between tropical and temperate ecosystems[1], with the Amazon Basin being the most rich tropical environment on Earth, containing as many as 11,210 tree species >10cm in diameter[2]

•Floodplain ecosystems likewise contain a higher density of trees, in both number and species, than anywhere else in these tropical environments[3]

•Arthropod diversity has been shown to correlate strongly with plant and animal diversity[4], as well as overall ecological health.[5]

•Our purpose is to understand the diversity, distribution, and dynamics amongst the 4 sub-ecotypes (Low Restinga, High Restinga, Bajial, and Palm Swamp) of the Peruvian Tahuayo River lowland floodplain forest by examining the integration between tree abundance and diameter at breast height (DBH), and arthropod diversity at ground level (Fig. 1 and Fig. 2A). It is expected , then, that:

1) The tropical floodplain, specifically the Tahuayo River lowlands, should contain a higher diversity and abundance of trees than their temperate counterparts; and

2) There should be higher arthropod diversity correlating with the density and diversity seen within tree species

Methods:

•Three, half-hectare plots were chosen according to sub-ecotype

•The tree density, distribution ,and flood level of each plot was then mapped and recorded

•Insect traps were placed at 4 different locations within each plot, every location consisting of:

- •2 pitfall traps
- •2 hanging insect tape traps
- •1 flight interception trap

•Traps were collected every 24-32 hours and insects were categorized by Order, with characterization of distinctly different morphospecies

•Alpha and beta diversity were calculated using measurements of richness and Jaccard indices, respectively, in order to compare the arthropod distribution inside and between sub-ecotypes. All statistics were done using R statistical software.

References:

[1]Mittelbach, G. G., Schemske, D. W., Cornell, H. V., Allen, A. P., Brown, J. M., Bush, M. B., Harrison, S. P., Hurlbert, A. H., Knowlton, N., Lessios, H. A., McCain, C. M., McCune, A. R., McDade, L. A., McPeek, M. A., Near, T. J., Price, T. D., Ricklefs, R. E., Roy, K., Sax, D. F., Schluter, D., Sobel, J. M. and Turelli, M. (2007), Evolution and the latitudinal diversity gradient: speciation, extinction and biogeography. Ecology Letters, 10: 315–331. doi: 10.1111/j.1461-0248.2007.01020.

[2]Stephen P. Hubbell, Fangliang He, Richard Condit, Luís Borda-de-Água, James Kellner, and Hans ter Steege. (2008), How many tree species are there in the Amazon and how many of them will go extinct? PNAS 2008 105 (Supplement 1) 11498-11504; published ahead of print August 11, 2008, doi:10.1073/pnas.0801915105

[3]Hans Ter Steege, Nigel Pitman, Daniel Sabatier, Hernan Castellanos, Peter Van Der Hout, Douglas C Daly, Marcos Silveira, Oliver Phillips, Rodolfo Vasquez, Tinde Van Andel, Joost Duivenvoorden, Alexandre Adalardo De Oliveira, Renske Ek, Ramesh Lilwah, Raquel Thomas, Jessica Van Essen, Claudia Baider, Paul Maas, Scott Mori, John Terborgh, Percy NúÑez Vargas, Hugo Mogollon, Wilfried Morawetz. (2003), A spatial model of tree α-diversity and tree density for the Amazon. Biodiversity & Conservation, 12: 2255-2277. doi:10.1023/A:1024593414624

[4]Vojtech Novotny, Pavel Drozd, Scott E. Miller, Miroslav Kulfan, Milan Janda, Yves Basset, and George D. Weiblen. (2006), Why Are There So Many Species of Herbivorous Insects in Tropical Rainforests? Science 25 August 2006: 313 (5790), 1115-1118.Published online 13 July 2006, doi: 10.1126/science.1129237.

[5]Kremen, C., Colwell, R. K., Eriwn, T. L., Murphy, D. D., Noss, R. F. and Sanjayan, M. A. (1993), Terrestrial Arthropod Assemblages: Their Use in Conservation Planning. Conservation Biology, 7: 796–808. doi: 10.1046/j.1523-1739.1993.740796.

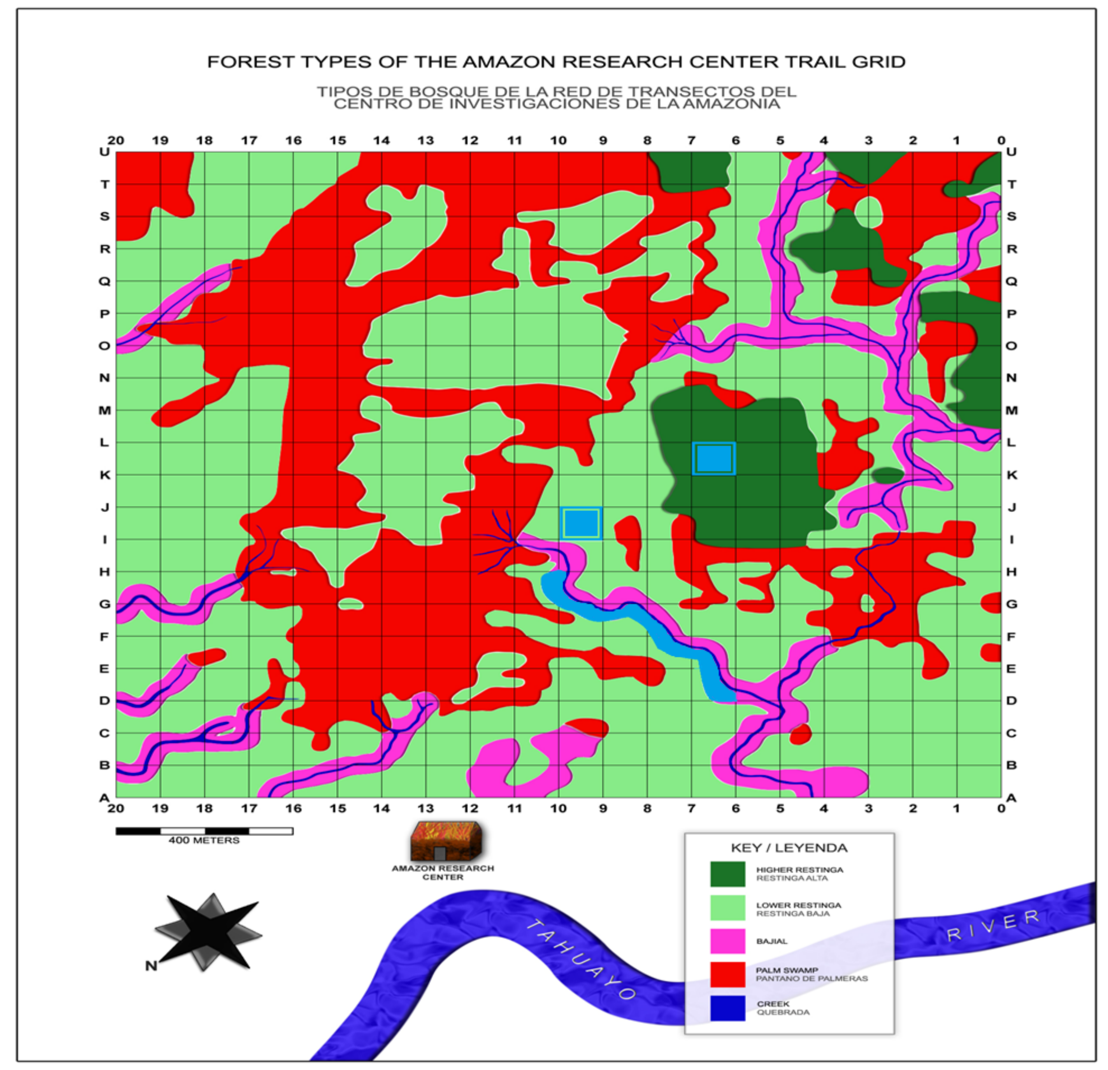

Figure 1. The half hectare (Ha) sites were part of the larger TRARC 2 km x 2 km trail grid along the Peruvian Tahuayo River, within the Tamschiyacu Nature Preserve. The High Restinga and Low Restinga were 50 m x 50 m plots, while the bajial half hectare was measured as 10 m from river, for 500 m in length.

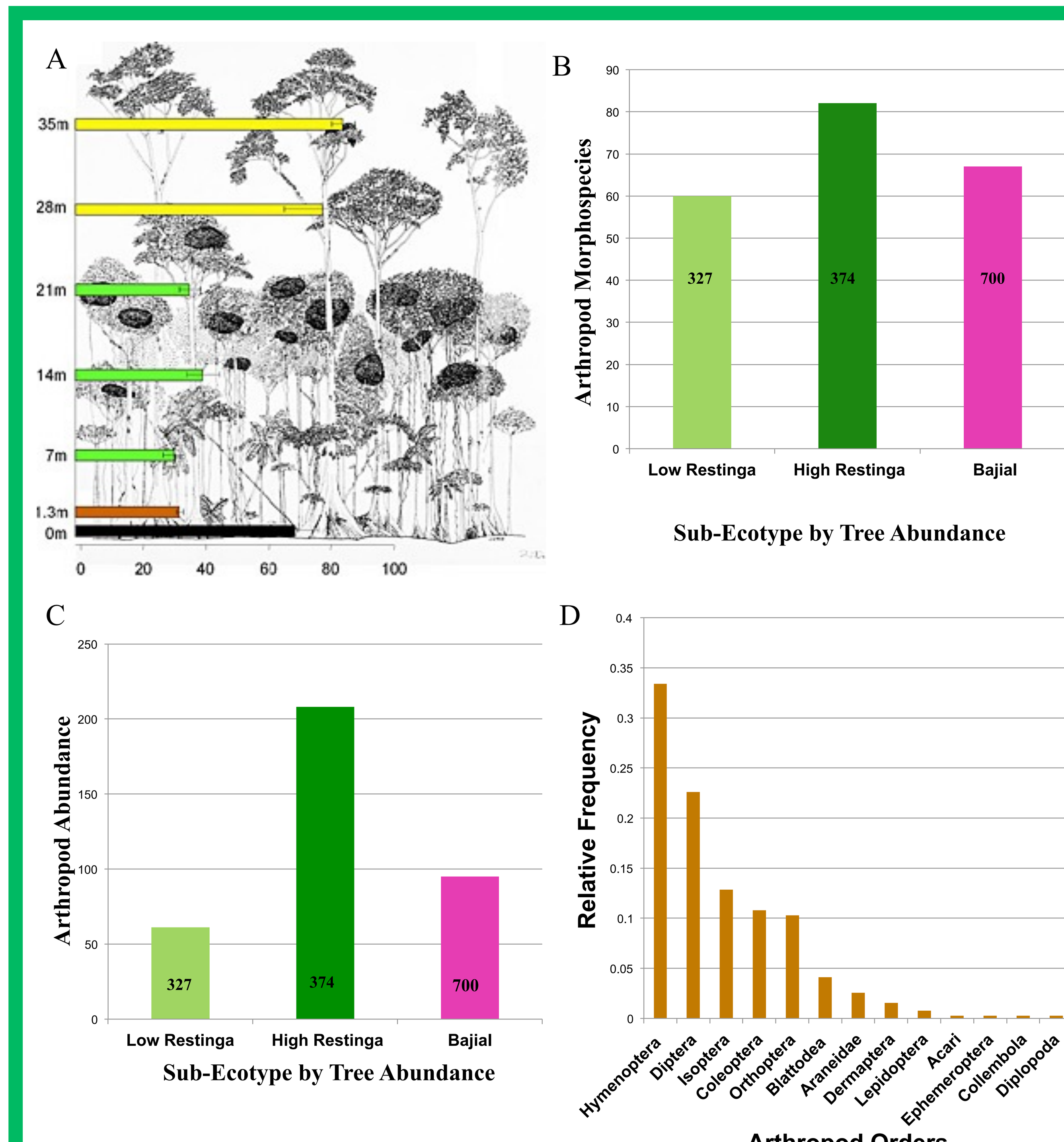

Figure 2. Diagram of vertical insect distribution in the rainforest (A). The spatial distribution of arthropod morphospecies (B) and abundance (C) in relation to tree abundance/0.5Ha in each sub-ecotype. Total frequency of arthropod orders across all sub-ecotypes (D).

Results and Discussion:

Figure 2.

Spatial distribution and frequency of arthropod biodiversity positively trends with elevational changes in the sub-ecotypes (Fig 2B and C). Areas with the most severe flooding (Bajial and Low Restinga) displayed markedly less abundance and diversity as compared to the area with little to no extended flooding (High Restinga). This could be due to submersion of the forest floor and destruction of the arthropod micro biome through limited ground access, elimination of food sources, and anoxic conditions for developing offspring. Complete flood inundation of the Low Restinga and Bajial results in very little difference between the diversity and abundance of arthropods in the two sub-ecotypes (Fig 2B and C). Conversely, infrequent flooding of the High Restinga results in a stable and hospitable biome for macroinvertebrate life, as seen by the acute increase in biodiversity. The lack of strong positive correlation seen between tree abundance and arthropod species/abundance suggests that, while tree density is important in arthropod biodiversity, differential flooding due to changes in elevation plays a larger role.

Figure 3.

The distribution of arthropod morphospecies also weakly correlates with average DBH of each sub-ecotype (A). This result is mirrored by arthropod abundance (B). This increase could result from the ability of trees to act as "hosts" to a multitude of arthropod species. Sub-ecotypes with larger average diameter, then, are able to accommodate a larger number and diversity species.

Table 1.

As expected, the overall arthropod diversity (alpha) was high across the floodplain. However, diversity between sub-ecotypes (beta), measured through a Jaccard index, showed <1% overlap between any sub-ecotype, as well as within any sub-ecotype. Such dissimilarity suggests an enormous amount of biodiversity not only throughout the sub-ecotypes as a whole, but also within any given half Ha. Though previous studies have shown there to be little beta diversity across sub-ecotypes, the data collected is thus far too minimal to make any assertions as to the overlap. Nonetheless, these indices, along with the strong correlation between tree and arthropod distribution, suggest that the Tahuayo River watershed has experienced little ecological disturbance and is in a healthy state.

Future work:

It is vital to all of us to preserve the lowland floodplain forest in a healthy state. Our goal is to develop a longitudinal study that establishes a baseline estimation of the tree and insect diversity within all four sub-ecotypes of the lowland floodplain forest, in hopes of improving understanding and subsequent management decisions.

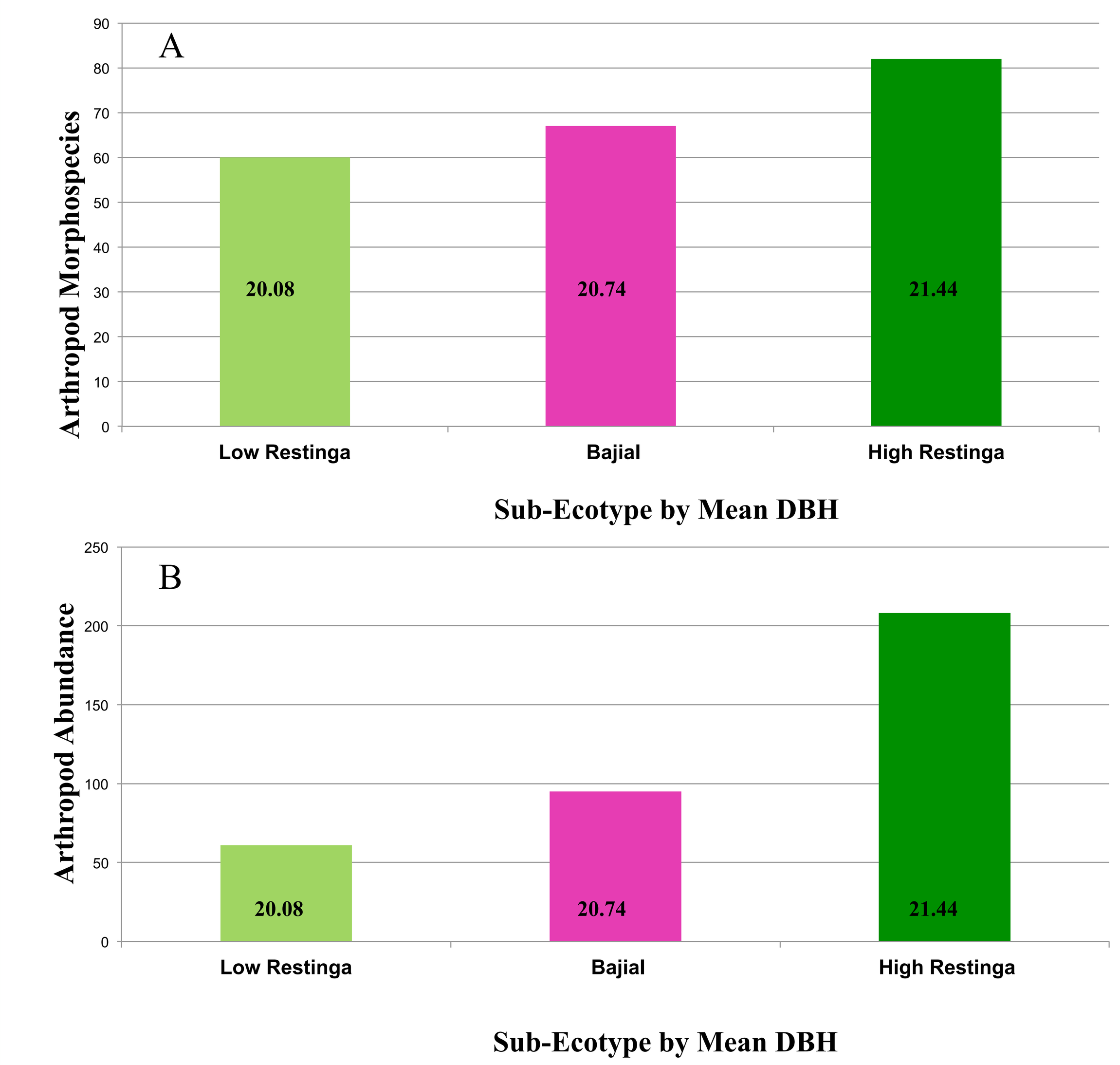

Figure 3. The spatial distribution of arthropod orders (A) and abundance (B) in relation to average tree diameter (DBH, cm) within the 3 sub-ecotypes (±.68 SD) .

Order Mean DBH:	# Species, Bajial, 20.08 cm	# Species, Low Restinga, 20.74 cm	# Species, High Restinga, 21.44 cm
Hymenoptera	13	17	33
Orthoptera	5	9	18
Diptera	6	7	5
Araneidae	4	1	4
Lepidoptera	1	1	1
Coleoptera	7	14	8
Dermaptera	3	0	1
Acari	1	0	0
Ephemeroptera	1	0	0
Collembola	0	0	1
Diplopoda	0	0	1
Isoptera	0	0	1

Table 1. The number of distinct morphospecies within each order, collected in each sub-ecotype of the Tahuayo River floodplain. Alpha diversity was calculated to be Bajial (B) = 41, Low Restinga (LR) = 49, and High Restinga (HR) = 73. Beta diversity was calculated to be 0.990 between HR and B, 0.993 between LR and B, and 0.996 between LR and HR.

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