Orographic gradients in climate and forest cover at the Cordillera Yanachaga, Peru

Damien Catchpole B.Sc. (Hons.)

Submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy

University of Tasmania, November 2012
In memory of my dear mother-in-law Amy Chacón


Que descanses en paz

Cover illustration: photo by D.J. Catchpole, windward cloud forest of the Cordillera Yanachaga, Yanachaga-Chemillén National Park, Peru
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Damien Catchpole
Abstract

The Cordillera Yanachaga is a semi-isolated Andean range protruding into the Peruvian Amazon that houses an important area of montane cloud forests on both windward and leeward slopes. Despite the importance of these forests for biodiversity and the provision of ecosystem services for nearby populations, their orographic variation in climate and forest ecology had not been previously described. Climatic and forest parameters were studied along an orographic gradient consisting of three sites, a windward slope forest at 2400 masl, a ridge forest on the mountain pass at 2800 masl and a leeward slope forest at 2400 masl. Common climatic measurements and visibility were recorded from canopy towers within 1-ha vegetation sampling plots, from which environmental data and taxonomic, foliage and structural characters of all stems ≥5 cm DBH were collected.

Despite its orographic location, the leeward forest received marginally less rainfall than the ridge forest and considerably more rainfall than the windward forest. The temperature variation found was attributed to altitude and an afternoon Foehn effect, while the orographic variation in PPFD was very strongly correlated to fog frequency. The ridge and windward forests showed higher canopy fog immersion (c. 75%) and a higher frequency of simultaneous rain and fog events, while the leeward forest showed less fog immersion (c. 20%) and higher rain frequency. The ridge and windward forests were affected principally by easterly air masses, while the leeward forest showed signs of localized phenomena originating from the Oxapampa valley to the west. The leeward forest displayed more climatic variation and larger parameter ranges, which were reflected in greater species richness, basal area, canopy height, foliage area and leaf size. Floristic associations within plots reflected sheltered and exposed regions. Forests at all the sites had stem densities and basal areas at the lower end of those recorded in other regions.

At the leeward site, light and moderate fog events generally displayed diurnal temperatures and PPFD more similar to clear sky events than to rain events, reflecting the warm clear upper atmosphere conditions under which they form. Dense fog events tended to mimic microclimatic conditions during rainfall events, albeit with higher PPFD.

In addition to the very strong correlation between fog frequency and PPFD, PPFD also correlated very strongly with total arboreal foliage area, suggesting as possible relationship through limitations on the development canopy substrata. While the mechanism for such a relationship remains unclear, the observations contribute to the existing theory that the effect of fog frequency on light conditions is one of the major drivers of variation in tropical montane forest productivity.
Resumen

La Cordillera Yanachaga es una cadena montañosa andina, semi-aislada por extenderse en el territorio de la amazonía peruana. Alberga un área importante de bosques montanos de niebla en sus flancos barlovento y sotavento. A pesar de la importancia de estos bosques para la biodiversidad y la provisión de servicios ecosistémicos a poblaciones cercanas, su variación orográfica en clima y ecología no han sido descritas previamente. Se estudió los parámetros climáticos y boscosos a lo largo de una gradiente orográfica que consistió en tres sitios, bosque barlovento a 2400 msnm, bosque de cresta a 2800 msnm y bosque sotavento a 2400 msnm. Se grabó mediciones climáticas estándares y visibilidad desde torres del dosel dentro de parcelas de vegetación de 1-ha, en las cuales se registraron datos ambientales y caracteres taxonómicos, de follaje y estructurales de todos los tallos ≥5 cm DAP.

A pesar de su ubicación orográfica, el bosque sotavento recibió levemente menos lluvia que el bosque de cresta y una cantidad considerablemente mayor al bosque barlovento. La variación en temperatura hallada se atribuyó a la altitud y un efecto Foehn postmeridiano, mientras la variación orográfica en radiación fotosintéticamente activa (RFA) fue altamente correlacionado a la frecuencia de neblina. Los bosques de cresta y barlovento presentaron una frecuente inmersión del dosel por neblina (c. 75%) y una mayor frecuencia de eventos de neblina y lluvia simultanea, mientras el bosque sotavento presentó menos inmersión por neblina (c. 20%) y mayor frecuencia de lluvia. Los bosques de cresta y barlovento fueron afectados principalmente por masas de aire orientales, mientras el bosque sotavento demostró señales de un fenómeno localizado originado desde el valle de Oxapampa hacia el oeste. El bosque sotavento presentó mas variación climática y mayores rangos de parámetros, lo cual fue reflejado con mayor riqueza de especies, área basal, altura del dosel, área del follaje y tamaño de hojas. Las asociaciones florísticas dentro de las parcelas reflejaron sitios protegidos y expuestos. Todos los bosques tuvieron densidades de tallos y áreas basales menores en comparación con bosques comparables de otras regiones.

En el bosque sotavento, generalmente los eventos de neblina tenue y moderada demostraron temperaturas y RFA con mayor semejanza a los eventos de cielos despejados que a los eventos de lluvia, reflejando las condiciones atmosféricas cálidas y despejadas en las que se forman. Los eventos de neblina densa demostraron similitud a las condiciones microclimáticas durante eventos de lluvia, aunque con mayor RFA.

En adición a la correlación muy fuerte entre frecuencia de neblina y RFA, RFA también tuvo una correlación fuerte con el área total del follaje arbóreo, sugiriendo una posible relación a través de limitaciones al desarrollo de substratos en el dosel. Mientras que el mecanismo para la supuesta relación no es claro, las observaciones contribuyen a la teoría existente que el efecto de la frecuencia de neblina en las condiciones de luz es uno de los factores claves para la variación en la productividad de bosque montano tropical.
Acknowledgements

This work would not have been possible without the support of many organizations and the collaboration and assistance from countless number of people, too many to be able to list all names and undertakings accurately and I apologise for any omissions.

I reserve my deepest gratitude for my wife Yoshie, not only did she help collect and process data, but she has been my pillar of support during all phases of the project and provided me with the motivation and encouragement required to continue on.

I thank all the students and colleagues who worked at the site over the 4-year field period that directly or indirectly assisted in the installation of infrastructure and data collection, including Chris Blackman, Rolando Gutierrez, Nicolai Koebernick, Yhuller Moya, Jimmy Requena, Jerry Romanski, John Switzer and Matt Taylor.

I thank Carlos Llerena of the Universidad Nacional Agraria La Molina for his friendship and institutional support over the last 10 years, without which this project may not have occurred. I also thank Michael McClain of Florida International University who provided initial opportunities in my previous projects, as well as financing for the part of the first meteorological station installed during my Honours project.

I am indebted to my supervisors Jamie Kirkpatrick, Manuel Nunez and Mick Russell for their generous support and advice, and especially for believing in me when others might not have, as well as Lorne Kriwoken, Emma Pharo and countless staff and students at the School of Geography & Environmental Studies for all their advice and assistance.

This study would not have been feasible without the local support from the Peruvian office of the Missouri Botanical Garden in Oxpapampa. I am deeply grateful to Rodolfo Vasquez, Rocio Rojas and Abel Monteagudo for their support, advice, friendship and generous provision of an internet connection and a four-wheel-drive vehicle for transporting equipment, as well as their countless students, staff and botanical specialists who in one way or another have assisted in the processing and identification of the thousands of botanical samples, as well as the initial delimitation of one of the study plots. Some of these people include Edwin Becerra, Lizeth Cárdenas, Franco Mellado, Adrian Tejedor amongst others. Special thanks also go to Antonio Peña who assisted students with the collection of foliage samples from large trees.
I would like to thank Benjamin Kroll and staff of the Oxapampa office of Pronaturaleza, who generously provided the permanent use of trail bikes for accessing the sites, as well as four-wheel-drive vehicles for transporting equipment.

I would like to thank both Yanachaga-Chemillén National Park chiefs Billy Huggard and Eduardo de la Cadena for their assistance and generous provision of four-wheel-drive vehicles for transporting equipment, as well as the many Park Rangers who assisted with constructing the project infrastructure and spent many a night accompanying me in the forest.

I thank both Instituto del Bien Común Oxapampa Project directors Percy Summers and Federico Rizo for their friendly assistance, provision of information and generous provision of four-wheel-drive vehicles for transporting equipment, as well as their many staff who were always helpful.

I thank Pedro Aguilar for his friendship, advice and general helpfulness in all matter of things. I am grateful to my lead field assistant Guido Casimiro for his friendship, support and tireless efforts in the field and laboratory during the fieldwork for this and many other associated projects. I would also like to thank the people of Oxapampa for their general friendliness, especially the 60 or so who were contracted over the project duration for the fabrication, construction and installation of field infrastructure.

I would like to thank Tony Sanford for his support and understanding in providing me with limitless time off work for the redaction of this thesis, as well as Lina Cuevas who helped with map production.

I thank two anonymous examiners for their comments and corrections of the manuscript.

Last but far from least, I deeply thank my extremely supportive family who have always provided me with encouragement, love, support and money whenever I have needed it during my adventures and in difficult times.

This work was financed by the School of Geography & Environmental Studies research funds and the University of Tasmania through an Australian Postgraduate Award scholarship. Some of the epiphyte related work not presented in the current thesis was partly funded by the American Orchid Society (USD 6,000), the South Florida Orchid Society (USD 2,000) and the San Diego County Orchid Society (USD 4,000).
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