

A black and white photograph of a mountain range. The foreground and middle ground are covered in dense, dark forest. Mist or low clouds are rising from the valleys between the mountains, partially obscuring the lower slopes. The sky is overcast with soft, diffused light. The overall mood is serene and atmospheric.

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

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

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In memory of my dear mother-in-law Amy Chacón

12.10.1940 – 22.12.2009

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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A handwritten signature in black ink, appearing to read 'D. Catchpole', with a stylized, cursive script.

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 a 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 amazonia 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 sustratos 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.

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