Ecology of bird communities along an elevational gradient in Papua New Guinea

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Introduction

Elevational gradients continue to provide an attractive setting for biodiversity studies and serve as a heuristic tool and natural experiment in the study of community ecology.

In this study, we examine bird species richness and abundance along one of the few complete undisturbed elevational gradients of tropical rainforest of Papua New Guinea, a region poorly surveyed for birds in the past.

We examine whether available area, regional species pool, mid-domain effect, contemporary climate, or habitat complexity determine species richness of birds along a complete, undisturbed forest elevational gradient.

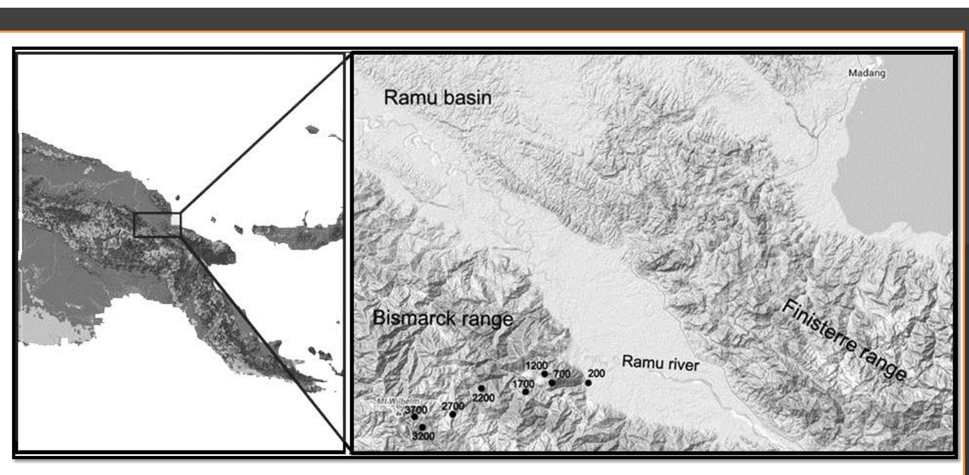
To disentangle the effect of these factors on bird species with different ecologies, we use species richness for five feeding guilds – frugivores, frugivore-insectivore, insectivores, insectivore-nectarivores, and nectarivore.

We also investigate abundance of birds from those five feeding guilds.

Location

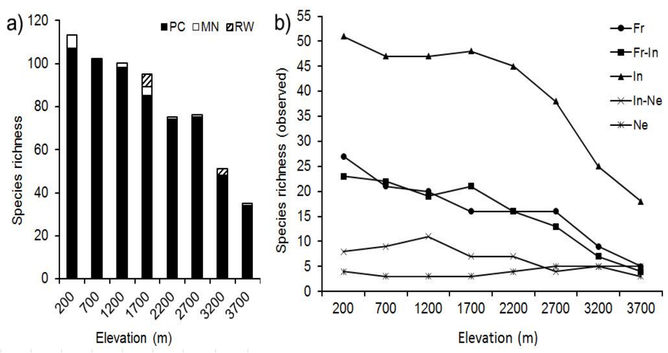
Slopes of Mt. Wilhelm (4509 m a.s.l.) in Central Range of Papua New Guinea, extending from the lowlands floodplains of the Ramu river (200 m a.s.l., S5° 44' E145° 20') to the tree line (3700 m a.s.l., S5° 47' E145° 03').

The study was completed along a 30 km long transect with eight sites, evenly spaced at 500 m elevational increment.



Results

We observed total of 33,639 bird individuals of 248 species during four surveys in 2010-2013. During point counts and random walks, we recorded 241 species, and we mist-netted 1,354 individuals of 105 species. In contrast to other existing studies, species richness of insectivorous bird decreased quite slowly with increasing elevation.

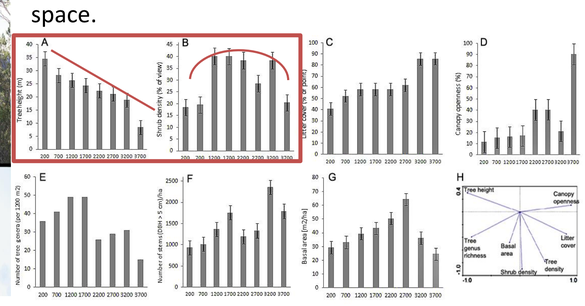


Species richness at elevational sites partitioned according to survey methods (a) and feeding guild (b). PC – point count (a priori selected as the main survey method, all species recorded by PC), MN – mist-netting (species recorded from nets but not PC), RW – random walks (birds observed during random walks but not PC or MN).

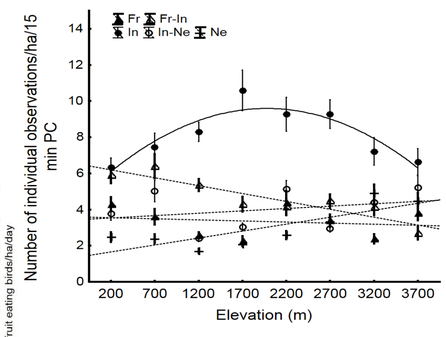
We found strong support for the effect of habitat complexity on insectivorous, frugo-insectivorous birds and also on overall species richness. Surface area available per elevational belt or species pool were also positively correlated with species richness. However, fits of models were relatively poor, and did not show a directly proportional relationship. Species richness was positively related to contemporary climate represented by local temperature and humidity.

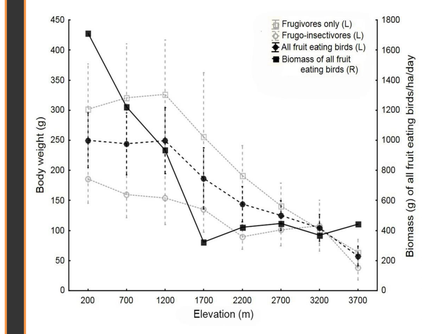
	Log-likelihood	R^2	Akaike weight (w_i)	AIC_c	ΔAIC_c
Total species richness					
Habitat	1.000	0.995	0.695	62.103	0.000
Climatic	0.201	0.964	0.140	65.312	3.209
Area	0.094	0.910	0.066	66.828	4.725
Insectivores					
Habitat	1.000	0.998	0.371	55.592	0.000
Species pool	0.756	0.898	0.281	56.150	0.558
Area	0.602	0.866	0.223	56.608	1.016
Frugo-insectivores					
Habitat	1.000	0.890	0.344	48.236	0.000
Area	0.902	0.857	0.310	48.442	0.206
Species pool	0.526	0.963	0.181	49.521	1.286
Frugivores					
Area	1.000	0.942	0.563	45.614	0.000
Species pool	0.332	0.900	0.187	47.818	2.204
Climatic	0.215	0.989	0.121	48.689	3.075
Insecto-nectarivores					
Species pool	1.000	0.880	0.649	37.635	0.000
Area	0.392	0.632	0.255	39.506	1.871
Species pool*Area	0.089	0.972	0.058	42.464	4.829
Nectarivores					
Species pool	1.000	0.449	0.476	32.990	0.000
Area	0.882	0.182	0.420	33.242	0.251
Species pool*Area	0.085	0.843	0.041	37.912	4.922

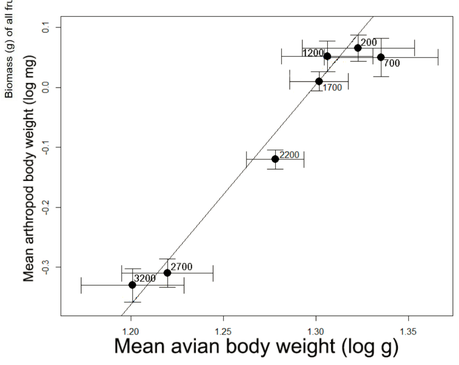
Tree height and the shrub density were selected as the most important factors explaining 80% of variability of habitat characteristics. While tree height is the highest in low elevation and decreases nearly linearly towards tree line, shrub density peaks in mid-elevations, representing thus spatial forest complexity in vertical as well as horizontal space.



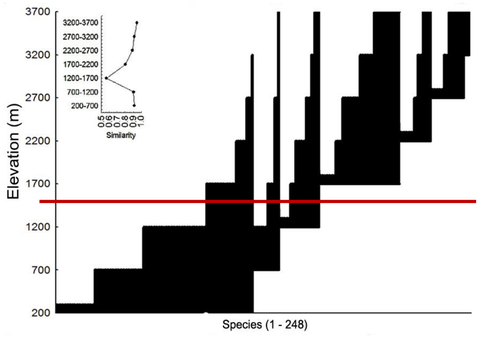
Elevational pattern in abundance of insectivorous birds differed from the patterns in abundance of all other feeding guilds.







Mean body weight and total biomass of frugivorous birds decreased steeply with increasing elevation. On the other hand, body size of insectivorous birds did not decrease too much up to 1700m, and decreased only at highest elevations. Body size of insectivorous birds correlated well with mean body size of arthropods occurring at given site.

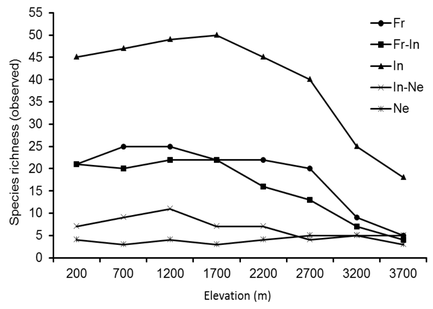


We observed the highest species turn-over at mid-elevations between 1200 and 1700 m asl.

Preliminary results – resurvey 2015

In 2015, strong El Nino shaped weather in Papua New Guinea, and severe droughts significantly influenced bird communities along the Mt. Wilhelm gradient. We recorded several significant shifts of ranges. Species richness patterns differed from those observed in previous years, and correlated with available humidity.

Patterns in species richness 2015



Conclusion

We observed a negative relationship between species richness of birds and elevation.

Most importantly, we documented that observed species richness **was positively correlated and best fitted with habitat complexity**. In agreement with many other studies, we showed that such species richness pattern correlates also with contemporary climatic conditions, and with regional species pool.

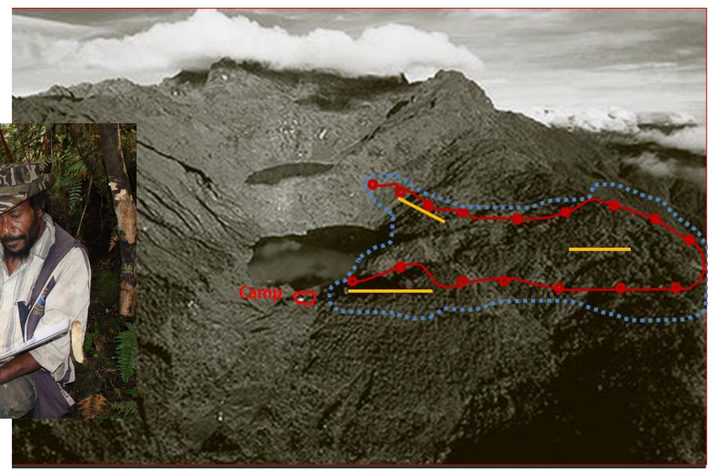
In contrast to existing studies, we did not find the insectivorous birds to have the most steeply decreasing species richness with increasing elevation.

Insectivorous birds correlated most strongly with habitat complexity, and are also likely to be influenced by habitat characteristics **indirectly via arthropods** living and feeding on the foliage, and representing food resources for birds.

In contrast to insectivorous birds, species richness and biomass of frugivorous birds decreased quite steeply with increasing elevation.

Severe droughts during strong El Nino in 2015 led to elevational shifts of ranges of several birds species. Patterns in species richness along the elevational gradient also changed due to changes in contemporary climatic conditions.

Methods

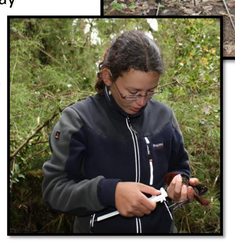


Point Count – 3+6+5 = 14 days
5:45 – 10:30
16 points 150 m apart – 1 point = 0.78 ha
15 minutes at point

Mist - Netting – 3+5+3 = 11 days
200m of nets 12 hours/day
5:30 – 17:30

Random Walks - 2 hours/day
Random walking around the area
14:00 – 17:30 and 6:00 – 8:00
20 hours at elevation – area = 70 ha

2015 resurvey -
3x point counts,
1x mist-netting



- Habitat complexity measured (tree basal area, density, coverage)
- Climatic variables (measured by data loggers placed at each site)
- Area available in New Guinea mainland (GIS)

Data on bird communities were collected at eight sites during three separate surveys encompassing dry and wet seasons over a two-year period. Communities were then resurveyed in November 2015, shortly before the beginning of the rains, and exactly 10 months after the droughts started. Birds were recorded using three methods – point counts, mist-netting and random walks. Five predictors of diversity were tested, including all sets of their interactions. Habitat complexity (e.g. shrub density, tree height, plant richness) and contemporary climate (local temperature and humidity) were locally measured, area available at elevational belts was obtained using GIS software, regional species pool was determined from literature.

Acknowledgements

I wish to thank to numerous field assistants from Kausi, Numba, Bundi, Bruno Sawmill, Sinopass and Kegesugl for help in the field and hospitality. Botanical plots were settled during Muséum National d'Histoire Naturelle de Paris / Pro-Natura International / Institut de Recherche pour le Développement – 'Our Planet Reviewed' Initiative, Papua New Guinea 2012-2103 Expedition, with help of Jean-Christophe Pintaud, Jean-François Molino, Kipiro Damas, Kenneth Molem and Hans Nowatuo. The project was financially supported by the Czech Science Foundation Grants 206/09/0115 and 206/08/H044, Czech Ministry of Education ME09082, Grant Agency of University of South Bohemia 136/2010/P and 156/2013/P, US National Science Foundation DEB-0841885, and was a part of Center of Excellence for Global Study of Biodiversity and Function of Forest Ecosystems, reg. n. CZ.1.07/2.3.00/20.0064 co-financed by the European Social Fund and the Czech Republic.