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

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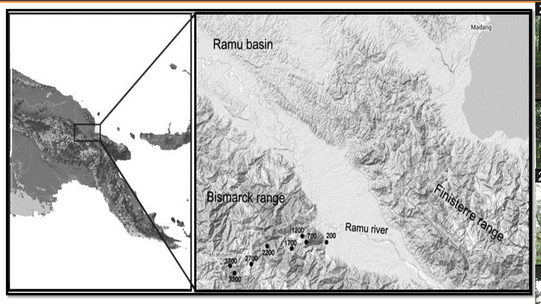
Elevational gradients continue to provide an attractive setting for biodiversity studies. In this study, we examine bird species richness, abundance, elevational ranges and feeding preferences of birds along one of the few complete undisturbed elevational gradients of tropical rainforest of Papua New Guinea.

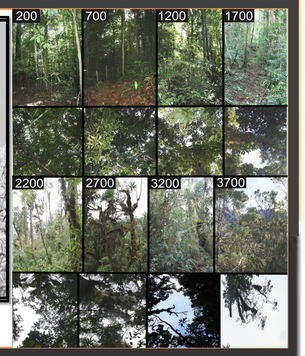
We tested whether available area, regional species pool, mid-domain effect, contemporary climate, or habitat complexity determine observed species richness. To disentangle the effect of these factors on bird species with different ecologies, we use species richness for five feeding guilds – insectivores (IN), insecto-nectarivores (IN-NE), frugivores (FR), frugo-insectivores (FR-IN) and nectarivores (NE).

We also investigated abundance of birds from these feeding guilds, and correlated them with food availability, Finally, we were interested whether parasites may also have effect on observed patterns in species richness or abundances.

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

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

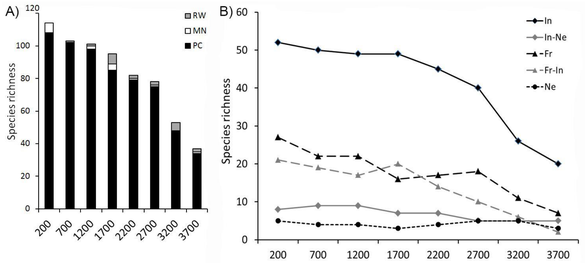




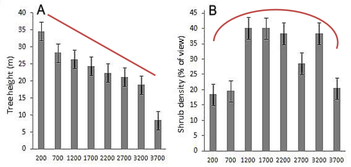
Left: Typical habitats and canopy openness at each study site

RESULTS

We observed total of 33,641 bird individuals and 241 bird species. Most of them were recorded during point-counts (PC), mist-netting (MN) and finally some birds were observed solely during afternoon random walks (RW). Insectivores were represented by 115, insecto-nectarivores by 16, frugivores by 50, frugo-insectivores by 42 and nectarivores by 11 bird species. Seven non-forest birds were excluded from some analyses.



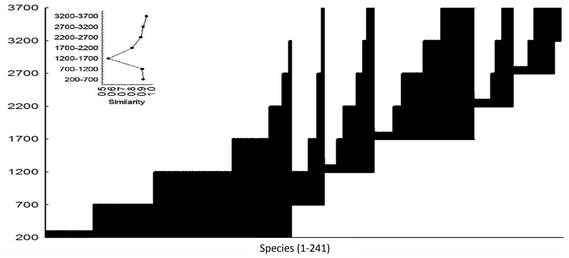
Species richness at elevational sites partitioned according to survey methods (A) and feeding guilds (B). PC – point count (a priori selected as the main survey method, all species recorded by PC), MN – mist-netting (species recorded from nets but not PC), RW – random walks (birds observed during random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



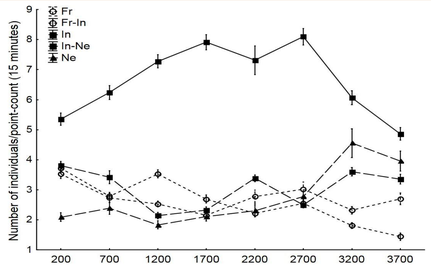
We found strong support for the effect of habitat complexity on insectivorous birds and also on overall species richness. Species richness was also positively related to contemporary climate represented by local temperature and humidity. Surface area available per elevational belt, local and regional species pool were positively correlated with species richness. However, fits of models were relatively poor. Species richness had very low concordance with the mid-domain effect predictions.

Tree height and the shrub density were selected as the most important factors explaining 80% of variability of habitat characteristics.

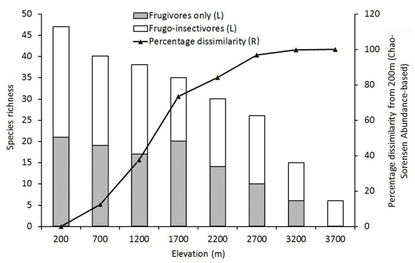
Most (60%) of the species recorded along elevational gradient were observed in the lowlands, and birds had the highest species turnover between 1200 -1700 m asl.

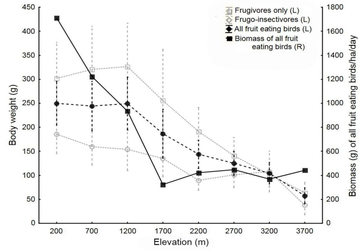


Abundance of some important insect groups (i.e spiders, beetles …) showed similar abundance pattern as abundance of insectivorous birds. Also frugivores seems to be influenced by availability of their food along elevational gradient. The bird species richness showed similar trend as relative species richness of *Ficus* trees, which represent dominant feature of New Guinean forest.



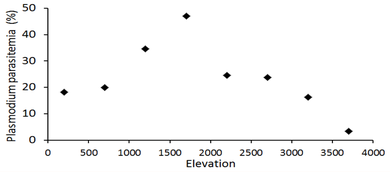
Insectivores were most abundant at mid-elevations.





Richness of frugivorous birds decreased much more steeply than richness of insectivores. The effect was apparent especially for large-bodies frugivores, and their total biomass. This has direct effect on distribution on distibution of *Ficus* trees (Volf et al., in prep.)

Finally, we molecularly screened blood from all mist-netted birds. Plasmodium was the most prevalent parasite, and Leucocytozoon was found only in 5 samples. Parasitemia was most prevalent at mid-elevations.



CONCLUSION

We observed a negative relationship between species richness of birds and elevation. 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. **We suggest that observed richness patterns were shaped by habitat characteristics and biotic interactions.**

Insectivorous birds are also likely to be influenced by habitat characteristics **indirectly via arthropods** living and feeding on the foliage, and representing food resources (K Sam et al., L Sam et al., both in prep.).

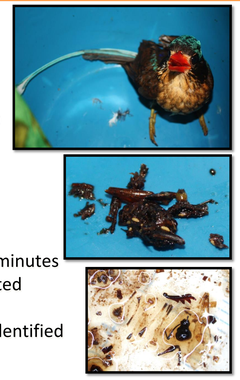
Abundances and species richness of *Ficus* species decreases towards 1200 m asl. (Sam, L., unpubl. data), which could **correlate with** the steep decrease in species richness of **frugivorous birds** along our gradient.

The highest species turn-over for all birds was observed between 1200 and 1700 m asl., which corresponded with high species turnover of *Ficus* trees, highest abundance of insectivorous birds, and highest prevalence of avian malaria parasites.

METHODS

Data on bird communities were collected at eight sites during three separate surveys encompassing both dry and wet seasons over a two-year period. Birds were recorded using three methods – point counts, mist-netting and random walks throughout a standardized area. 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 and mid-domain effect was simulated from empirical ranges. We used emetic tartar to obtain food samples from birds, and we identified more than 5,600 insect individuals from obtained food samples. For all insect, we estimated body length. We counted proportion of fruits vs. insect in each samples and consulted our data with literature. We isolated DNA from blood of all birds, barcoded all blood samples, and sequenced all samples where malaria parasites were confirmed.

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
Food survey – all mist netted birds
Emetic tartar injected , birds kept for 10 minutes in resting bowls, insect from samples sorted and insect body size estimated.
Malaria parasites survey – molecularly identified from blood samples



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). Insect (K.Sam *et al.*, in prep) and *Ficus* abundance and species richness (L. Sam *el al.*, in prep) were surveyed.

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