



## Fakultät für Lebenswissenschaften

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### **Review of the PhD thesis submitted by Pagi S. TOKO MSc**

Tropical forests are global hotspots of biodiversity, and this applies particularly for tropical mountains. Despite decades of intense research many facets of the mechanisms behind this stunning diversity remain poorly understood. At the same time, these ecosystems are under severe threat due to over-exploitation or destruction. The PhD thesis of Pagi Toko aims at contributing to both lines of research, (a) a better understanding of patterns and mechanisms underlying tropical biodiversity and (b) ways towards more successful conservation approaches. As is usual today, the thesis comprises several chapters, designed for being published as separate journal articles, in all cases with a number of co-authors. The first chapter has already been publicized in a sectoral journal of high reputation (incidentally, I served as one of the peer reviewers in this case), the second has not yet been submitted, and the third is in revision after a first round of review.

In the first chapter, the authors use local assemblages of insects from one speciose moth family, surveyed along a complete forested tropical elevational gradient in Papua New Guinea (PNG), to assess species diversity patterns and their possible drivers. Since similar studies have been performed on the same target taxon (Geometridae) in other tropical as well as non-tropical regions, such an endeavour lends itself for manifold comparative perspectives. Field work under truly demanding circumstances consisted of intense sampling by manual light-trapping, followed by thorough taxonomic evaluation of the samples combining morphology with DNA barcodes. Subsequently, patterns of alpha, beta and gamma diversity were explored using adequate statistical methodology. In many ways, the results confirm findings from earlier studies, such as a rather broad diversity peak at mid elevations. Moth abundance turned out to be almost uniformly high and declined only at the highest elevation. Alpha as well as gamma diversity reached high values (as expected for tropical mountains), while similarity in species composition decayed monotonically with increasing elevation (again as expected). Compositional turnover among geometrid assemblages was clearly related to variation in ambient temperature, vegetation composition and abundance of putative predators. Yet, as is usually the case with such correlative studies the statistical models failed to identify an unequivocal hierarchy among these potential drivers. The power of statistical analyses were, however, hampered by the low number of sampling units and the comparatively large number of potential predictors, that also are correlated to each other. Overall, this chapter is a neat piece of work on tropical insect species diversity, also well embedded in current literature and uncovering diversity in an absolutely under-explored tropical region. However, one might have expected a bit more detailed comparisons with existing similar case studies. For example, total observed as well as estimated species richness along the complete PNG transect was substantially lower (<1200 species) than in a much shorter Andean gradient (>1800 species), and a continuously high geometrid abundance within the mountain forest zone had also been reported earlier from this same Andean landscape. In the statistical modelling, important potential predictors were unfortunately not included (viz. area size and the role of mid-domain effects). Also, given the large number of predictors relative to units of analysis, consideration

of alternative modelling approaches (such as partial least squares regressions PLS or generalized additive models GAM) might have been a valid option.

The second chapter presents results from a study with very similar approach and scope, but from a far less extensive, incomplete elevational gradient on the neighbouring island New Britain. Here, the gradient extended only from 500-1100 m a.s.l., with samples taken at every 200 meters of elevational difference (as opposed to 500 meters difference on Mt. Wilhelm). Obviously, this sampling design results in a severely reduced statistical power. Moreover, the entire set of study sites falls within the elevational diversity peak revealed on PNG's mainland. Accordingly, there was practically no variation in alpha diversity observed. Yet, even along this reduced gradient length geometrid species composition revealed a significant signal that could be related to variation in ambient temperature and vegetation. This observation underpins that often times species composition carries more information along ecological gradients than mere richness or local diversity. As with the first chapter, this local case study is a sound and pioneering study on the biodiversity of an under-explored fauna. A rather substantial fraction of species was shared between both gradients. These species also tended to show similar abundance relationships. This finding is tentatively interpreted as an indication of connectivity between New Britain and PNG's mainland, but it could be equally well explained by parallel responses of widespread moth species to the same environmental factors, such as perhaps variation in rainfall. I regret that no faunal surveys were undertaken in the "disturbed" forest remnants at elevations below 500 m on New Britain, since in other tropical regions secondary or impacted forests have turned out to harbour surprisingly rich geometrid assemblages. It would have been interesting to learn whether, and to what extent, this might also apply to PNG's rich geometrid fauna. Given the ever-increasing importance of secondary or rehabilitated ecosystems in the tropics, such information could have substantial implications for conservation biology and scientifically informed management suggestions. It needs to be seen whether the authors will finally succeed in publishing this chapter in an international outlet. The low level of spatial replication and, accordingly, the limited statistical power of any analytical attempts might turn out as an obstacle here.

The third thesis chapter is of entirely different nature. Instead of presenting and discussing results from empirical field or lab work, this part rather can be characterized as an essay about ways to improve conservation efforts in tropical areas, by better integrating indigenous Peoples and their knowledge and needs. This essay largely draws on aspects related to economy, politics, sociology and jurisdiction. As an empirical animal ecologist, I do not feel qualified to scientifically rate the arguments and suggestions developed in this chapter, but subjectively my impression was very positive. This chapter is obviously built upon a large amount of up-to-date literature sources. It also pulls together experience of scientists representing indigenous Peoples otherwise (unfortunately!) not often seen as participants in these ecological debates.

To place these three thesis chapters into a solid framework, a broad introduction forms the first part of this thesis. This gives an excellent overview of the state of the art with regard to understanding the mechanisms behind tropical biodiversity, but also highlighting the challenges for tropical conservation in the 21<sup>st</sup> century. I found this introduction really inspiring to read. In contrast, the thesis summary at the end is kept very brief. I do not know whether this is the usual (or even mandatory?) way at the University of South Bohemia. At "my" university in Vienna, PhD candidates are expected to pull the findings from their individual chapters together in a more synthetic manner, but obviously this depends on policies that may well differ between faculties or institutions.

At any rate, I recommend this thesis to be accepted in partial fulfilment of the procedures granting the degree of PhD to the applicant Pagi Toko.

I was also asked to identify 3-4 questions in preparation of the thesis defence. These are listed below:

- You have observed a very substantial turnover in the subfamily composition of local Geometridae ensembles with elevation. This suggests that the phylogenetic structure of the communities changes dramatically. Very similar patterns have been observed on tropical mountains elsewhere. What elevational patterns would you expect to see if you study suitable metrics of

phylogenetic diversity (instead of species richness) along your gradients on Mt Wilhelm and the Whiteman Range?

- Your analyses are based on rarefied species richness per site. Since at one site (highest elevation) you sampled far fewer individuals (as expected) than at all others, this has resulted in quite some loss of information. Would the results of your analysis (Figure 2b and Supplementary Table S1 in Chapter 1) change if you instead use a species richness estimate at an 'intermediate' standardized sample size (e.g. 1500 or 2000 individuals per site), or the (bias-corrected?) exponential Shannon diversity as response variable in your modelling?
- Your results suggest an inverse Rapaport pattern with regard to the elevational ranges of the moth species, with on average more narrowly distributed species occurring at higher elevations (i.e. in colder and more harsh environments for ectothermic insects). How does your observation fit to results obtained in similar studies, and what could be a mechanistic explanation?
- Did you observe any consistent trends in eco-morphological traits of Geometridae moths with elevation, such as body size, colour lightness, or alike? These traits have been explored in macro-ecological studies along climatic gradients, using the same family as target.

I hope that this thesis review assists the Faculty of Science at the University of South Bohemia in handling the application of Pagi Toko MSc for being granted the degree of PhD. I am looking forward to contribute to the final thesis defence.

Yours sincerely

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