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PhD Dissertation
Ecological and Biogeographical Drivers of Afrotropical Lepidoptera Biodiversity
by
Sylvain Delabye

COMMENTS AND QUESTIONS BY 'OPPONENT' PROFESSOR ROGER KITCHING

I have read the submission by Mr Delabye comprising seven published papers and one unpublished manuscript. I suggest that the quality and importance these works, together, are sufficient to justify the AWARD OF THE DEGREE – and I recommend accordingly.

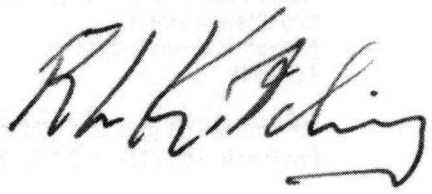
Eight of the nine Chapters are papers that either have been published or are 'in press'. The eighth is presented as a manuscript 'ready' for publication – more of that shortly. As an examiner I am aware that the published papers have all been through journal evaluation processes by reputable journals that are generally accepted to be thorough and adequate – these must be evaluated somewhat differently from a totally unpublished manuscript. Five of the eight submissions have Mr Dalabye as first author. I note, also, that one of these (Chapter 5) reflects work done as part of Mr Delabye's undergraduate studies in France although clearly published (in 2019) during his PhD candidature and, presumably written up as part of that training process.

Chapter 4, the unpublished manuscript, is an important comparative study on the relationship between productivity and species richness of macromoths in southern African savannahs. The writing still needs editorial attention and the English needs correcting and polishing. Nevertheless this paper may be the most original and generally important of those included here. I urge Mr Delabye and co-authors to progress this work.

There are several specific and general questions that come to my mind after reading Mr Delabye's work. I have selected four of these here , one or two of which could usefully be the basis for discussion in the Examination.

1. When comparing any two locations, how do you cope with the *possibility* that trapping (sampling) efficiency might change between sites (eg. Light traps might attract at a farther distance in more open sites, etc.)?
2. What criteria do you use when selecting which taxa (among the moths or butterflies) to use to test your hypotheses?
3. What do you think is the 'next step' in the general approach that uses mass sampling of Lepidoptera (or any other group) to detect ecological patterns?
4. How might we connect biodiversity PATTERNS with ECOLOGICAL PROCESSES?

I shall prepare one or two additional questions for the day of the examination.



Professor R. L Kitching AM
DSc, DPhil, BSc, ARCS, DipComp

April 8th 2021

UCL GEOGRAPHY
DR JAN C. AXMACHER
ASSOCIATE PROFESSOR
BIODIVERSITY CONSERVATION AND
LANDSCAPE ECOLOGY

Re: Reviewer's statement, PhD thesis of Sylvain Delabye

To the
School of Doctoral Studies in Biological Sciences
Faculty of Science
University of South Bohemia in České Budějovice

Dear Sir or Madam,

As thesis reviewer appointed by the Faculty, I wish to submit the following evaluation of the PhD thesis 'Ecological and biogeographical drivers of Afrotropical Lepidoptera biodiversity', submitted by PhD Candidate Sylvain Delabye.

The thesis contains a highly impressive eight main chapters that each either represent already published manuscripts or a draft for such a manuscript – along with a general introduction and short, concluding summary. All main chapters represent joint work with multiple co-authors, and the candidate is first author on five of the resulting manuscripts. The thesis furthermore contains a summary of the candidate's independent contribution, and written confirmation by the main PhD supervisor and the other senior author on the included manuscripts of the candidate's respective contributions. Based on this documentation, I believe that the thesis and the candidate's contribution both clearly meet the requirements for a PhD dissertation.

Seven of the thesis chapters have already been published in peer-reviewed international journals, with one of these (Chapter I) listed in the thesis document as "in press", but now actually published (*Biotropica*, March 2021 volume). One of the chapters (IV) is yet to be published, but has been included in the thesis in the form of a relatively advanced manuscript draft that in my view is already nearing a 'submittable' standard. As can be expected, the published manuscripts are more polished and well-written than the unpublished chapter IV and particularly the introductory and summary sections of the thesis. Reflecting the breadth of the chapters that span from more ecology- and biogeography-focused to taxonomy-focused work, the introduction spans a broad range of subjects, albeit focusing quite strongly on ecological and biodiversity aspects. Some sections of the introduction could have been slightly more up-

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to-date with regards to most recent developments in the published literature, but the thesis in its entirety is in my view clearly of international quality.

As indicated already, the thesis reflects an extremely impressive amount of work – both in the field as well as in subsequent taxonomic/systematic work and associated data analysis that allows for strong and meaningful interpretations of emerging trends from the data. In my view, the content of this thesis therefore greatly contributes towards advancements in our understanding of moths and butterflies particularly on Mt. Cameroon, but also in other parts of Western parts of Africa. The links between lepidoptera and environmental factors on Mt Cameroon are the focus of the first three chapters, covering a wide range of different predictors related to plant diversity, forest structure and, specifically, forest openness in Chapter I. Chapter II then has a more limited, clear focus on the impact specifically of elephant-related forest disturbances, speculating what might happen if elephants disappear altogether and clearly establishing them as keystone species in the forests of Mt Cameroon. Chapter III, for me probably the most exciting of these first three chapters, then provides some highly novel and exciting insights into the seasonal diversity patterns and, crucially and for the first time, into seasonal range shifts of lepidoptera. With regards to novelty of the first two chapters, Chapter I arguably follows somewhat well-established analytical approaches into links between lepidopteran assemblages and parameters describing forest diversity and structure, while the novelty in my view relates to the simultaneous inclusion and direct comparison of fruit-feeding butterflies and moths, also differentiated by strata, in the same analysis. Chapter II is, as mentioned, more limited in scope by focusing on the links between elephants, plant and lepidopteran communities, but in doing so creates clearly novel and important insights into the role of elephants in the forests of Mt Cameroon, which have implications also for other forest systems that currently harbour elephant populations.

Chapter IV represents the only chapter not already published. Here, the study area is a large transect located in southern parts of Africa stretching from Namibian desert environments to much more productive woodland savannahs of NW Zimbabwe. This chapter therefore works on a much larger spatial scale, investigating how productivity – approximated using NDVI measurements – is linked to moth diversity patterns, characterized as plot-based (alpha) and site-based (10 plots, gamma) species richness, and mean species turnover (gamma/alpha=beta). Again, the results created are very interesting and novel, and in my view highly relevant not least with regards to potential climate change effects on lepidopteran biodiversity patterns.

The final four chapters are more strongly focused on taxonomy/systematics and regional species records/biogeography. As such, this is not my area of expertise and I hence find it more difficult to evaluate these chapters, but clearly, the knowledge and information presented in these four chapters is important for anyone working with moths in western tropical Africa,

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and these chapters provide novel information. Chapter V represents a study using DNA barcoding approaches to approximate the diversity of moth communities at two sites in Gabon. It highlights both the great number of species that are likely harboured by the two investigated environments and great persisting knowledge gaps with regards to moth species of Gabon, since the number of BINs established here is already greater than the respective known species pool of Gabon for these taxa. The large number of singletons (in the BINs) furthermore highlights that the data that is presented here is likely a highly incomplete representation of the moth fauna, emphasizing that the areas sampled are likely significant hotspots for lepidopteran diversity. Chapters VI and VII both provide updates on the distribution ranges of a number of moths and butterflies in SW parts of Africa (Chapter VI) and in Cameroon (Chapter VII), with further references to elevational ranges included in Chapter VII. A large amount of data is provided for the respective species in each of these two papers that are, as indicated above, of great interest in biogeographical terms, but also create a more thorough record of the overall levels of diversity in the respective families for the two study regions. Chapter VIII finally contains the descriptions of seven new species of Alucitidae from Mt. Cameroon. The novelty and importance of these descriptions of new species is in my view self-evident.

Overall, I was impressed both by the broad scope and by the novelty represented by the manuscripts contained in this thesis. The methods chosen are widely appropriate, very well applied and the results are clearly presented and skilfully analysed and contextualized. I hence like to congratulate the candidate for their impressive work.

Reviewers are asked to formulate a few questions for which the candidate is then given time to prepare answers. In this context, I would like to ask the candidate to prepare for the following questions:

1. Seeing the diversity levels reported generally in this thesis for moth families on Mt Cameroon, and also looking at my own research from Mt Kilimanjaro, it strikes me that both assemblages appear distinctly species-poor compared to other tropical mountain environments - for example in the Andes (see e.g. work by Gunnar Brehm and/or Nadine Hilt) or in Asia (e.g. work by Jan Beck or I-Ching Chen from Mt Kinabalu). Would the candidate agree with this assessment - and what are potential reasons for these patterns? Also, where does this leave us with regards to the statement (page 8) that "tropical ecosystems host tremendous Lepidoptera species richness"?

2. Chapter I: Both the herbaceous ground vegetation and trees are considered in this manuscript with regards to plant diversity. This leaves me wondering what the patterns are with regards to two other groups that can be important components in tropical forest vegetation: lianas and epiphytes? In tropical mountain rainforests, epiphytes in particular often increase in diversity with elevation at least towards mid-elevations (coinciding with precipitation patterns

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linked to cloud and fog formation). These plants could provide an important additional food source (nectar for adults and host plants for caterpillars). What potential expectations might we have in terms of links between overall plant diversity and butterflies / moths if epiphytes (and lianas) were included in such an analysis? Could some of the relatively poor links between plant diversity and especially butterfly diversity potentially be related to the lack of consideration for these plant groups?

On a different note, is the relatively strong link between plant diversity and moth diversity reported in this chapter linked to potential food plants, or could this also be a (micro-)climatic signal, i.e. an indirect link associated with both plants and moths responding in similar ways to the same (micro-)climatic gradient (e.g. ferns favouring wet microclimatic conditions)?

3. Chapter II: Picking up directly on the last thought – can the relatively low diversity in some lepidopteran taxa in more undisturbed, plant species-rich forests potentially be linked to increasingly wet microclimatic conditions? Also, if elephants disappeared from these forests, could / should selective logging be used as a means of creating a similar pattern of disturbance and openness to that currently created by elephants?

4. Chapter IV: If I understand correctly, the NDVI recorded at the beginning of the vegetation period is used in this chapter to approximate productivity of the vegetation. Is this the best way to link the NDVI and productivity? I would generally expect the NDVI recorded at the very end of the rainy season when the vegetation likely is "at its prime" and biomass reaches its maximum, to provide the strongest indication of productivity of an ecosystem? Furthermore, the specific nature of the relationship between NDVI values and lepidopteran diversity is investigated in this manuscript, comparing models for linear and non-linear response patterns. These results are then directly compared to other studies that looked at diversity-productivity links. That direct comparison in my view requires a direct, linear link to exist between NDVI values recorded at the beginning of the vegetation period and the actual productivity of a site. What is the evidence for such a linear link? As stated in this chapter, temperature and precipitation regimes might have provided a more direct indication of a site's productivity. With at least medium-resolution global data-sets available for both, temperature and precipitation, what are the respective advantages and disadvantages of using NDVI versus these climatic data-sets?

5. Chapter IV, but also elsewhere: Generally, moths and butterflies are highly mobile organisms, and especially in the tropics, samples of these taxa are rarely complete. For Chapters I-III, I believe it is stated that either completeness was nearly achieved and hence use of observed (rather than e.g. estimated) species richness was warranted, and/or proxies (species richness estimators like Chao 1, rarefaction or diversity indices) are used. What are the differences and potential limitations and characteristics of these different approaches, and

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what can/should be used in which scenarios? Furthermore, it appears that observed species richness patterns are also used in Chapter IV, while the structure of the data, as far as I understand it, to me suggests that these samples were not closely approaching completeness. What are therefore the potential implications – and alternatives – for that approach?

6. Finally, two more technical notes that I hope the candidate can briefly comment on:
a) Two of the chapters included in this thesis (chapters II and III) are first-authored by a former (completed in 2019) PhD student, Vincent Maicher, who I believe studied the "Biodiversity patterns of butterflies and moths on Mount Cameroon" for his PhD. He is also co-author of a further five chapters included in this PhD. Would the candidate please briefly reflect on this, outlining how these two PhD theses are linked – and how they can be differentiated?

b) Furthermore, if I understand correctly, chapter V of this PhD originates from work conducted in the framework of the candidate's MSc studies at the University of Rouen, France. I see that the second year MSc thesis submitted there (based on the CV included in the thesis) was entitled "Barcoding of moth communities in two contrasted Afrotropical environments in Lopé and Ivindo National Parks". How did the work subsequently conducted in the framework of the PhD studies inform this chapter, in addition to the work carried out already in the framework of the MSc studies?

Huntingdon, 05/04/2021

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