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Behavioral Ecology

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Review of the PhD thesis by M.Sc. Carlos Bautista

"Natural and anthropogenic drivers of brown bear damage occurrence"

Supervised by Dr. Nuria Selva Fernandez

The thesis submitted by C. Bautista contains three papers of which two have been published in well-known, high impact scientific journals and the last one has been submitted. The candidate is first author on all three articles.

Bautista, C., Revilla, E., Naves, J., Albrecht, J., Fernández, N., Olszańska, A., Adamec, M., Berezowska-Cnota, T., Ciucci, P., Groff, C., Härkönen, S., Huber, D., Jerina, K., Jonozovič, M., Karamanlidis, A.A., Palazón, S., Quenette, P.-Y., Rigg, R., Seijas, J., Swenson, J.E., Talvi, T. & Selva, N. (2019) Large carnivore damage in Europe: Analysis of compensation and prevention programs. Biological Conservation, 235, 308-316. doi: https://doi.org/10.1016/j.biocon.2019.04.019.

Bautista, C., Revilla, E., Berezowska-Cnota, T., Fernández, N., Naves, J. & Selva, N. (2021) Spatial ecology of conflicts: unravelling patterns of wildlife damage at multiple scales. Proceedings of the Royal Society B: biological sciences, 288, 20211394. doi: 10.1098/rspb.2021.1394.

Bautista, C., Oeser, J., Kuemmerle, T., & Selva, N. Resource pulses and human-wildlife conflicts: Linking satellite indicators and ground data on forest productivity to predict brown bear damages. Submitted to Remote Sensing in Ecology and Conservation.

The overarching topic of the thesis is to study costs, spatial distribution, and drivers of wildlife damages. Two of the three articles use the Carpathian brown bear population as a model while the third one compiles data across all four large carnivore species present in Europe. The thesis has a natural flow and all chapters fit into the overarching goal to better understand damages by large carnivores in Europe. The topic of the thesis is of high contemporary relevance as large carnivore populations are increasing across Europe and so are true and perceived conflicts humans.

I would like to highlight that this thesis is of exceptional overall quality. All three chapters take a different analytical approach. The first one necessitated to collect a substantial amount of national data on compensation payments, which likely involved

many months of correspondence with national agencies responsible for these compensation programs. The second article is surely footed in the field of spatial ecology with a clever and advanced analysis at three spatial scales. The last article harnesses weather, and remote sensing data and combines it with long term data on beechnut production and bear damages. To me, this demonstrates a great flexibility and curiosity of the candidate to learn and explore new analytical techniques, something that I find an important trait in a young researcher.

In the following I will go through the four chapters – the Introduction and each of the three manuscripts – and will give some specific comments which may also serve as discussions points during the thesis defence.

Chapter 1 - Summary and Introduction:
The summary and introduction provide a concise overview of the three studies that comprise the thesis and how they each contribute to the overarching goal to describe temporal and spatial correlates of wildlife damages. Following a general introduction and the state of the arts, the candidate outlined his research questions and explains interlinkages with the help of a schematic Figure.

- I missed a more specific definition of the term wildlife conflict and a subsequent explanation that the here presented thesis is limited to conflict through damages (ie bears foraging in agricultural fields, apiaries, lifestock) and does not extend to conflict resulting in human injury or fatalities. Further into the introduction you mostly use the term damages or conflicts arising through damages, which seems more appropriate.
- I further missed at least the mentioning of the concept of "food conditioning" (not to be confused with habituation). The term is mostly used in relation to dumpster or trash can raiding bears in the US but in a wider sense, bears also learn to exploit fields, apiaries and lifestock as food resources. If I understand it correctly, supplementary or diversionary feeding is common in the Carpathian bear population – these are anthropogenic food resources which are specifically not regarded as damages. Yet it would have been interesting to discuss at some point the relevance of damages (i.e. raiding apiaries) for the caloric input of bears in relation to supplemental feeding, beechnuts, and berries.
- I wonder if a paragraph on the consequences of damaging behavior (for the bear) would have highlighted the conservation urgency to the topic. If damages lead to the management removal of individuals or unregulated poaching this of course has negative population consequences. How is this currently regulated in the Carpathian population, is there legal hunting or poaching present?
- I would also have stated more clearly in the objective that the study is limited to Europe. This might be important because both the historical extinction history and the tolerance of people towards wildlife differs between Europe and North America. Of course, Europe is also a myriad of different countries, each with their own legislation and management objectives, along a stark gradient of economic wealth - it therefore provides a particularly interesting setting for your study (esp. chapter 2).
- For the second study (chapter 3) I found the use of the term "scales" and "multi-scale" confusing as it was not clear to me what kind of "scales" you were referring to. Reading on it becomes apparent that you are referring to a broad landscape scale, a local scale (similar to home range scale) and a household scale, I would have referred to these different scales more directly throughout the introduction.
- For study three I would have explained more specifically in the introduction what the phenomenon of masting is and in which plants it occurs. Specifically, masting first and foremost is a synchronized mass fruiting of plants of the same species in the same general area which only occurs every few years. Climate plays a role but is not the sole driving factor of masting cycles. Rather than framing the thirds study in relation to climate and climate change I therefore would have focused on describing the term masting better.

Chapter 2 - Large carnivore damage in Europe: Analysis of compensation and prevention programs, published in Biological Conservation

The first manuscript in the thesis has been published in Biological Conservation in 2019. The manuscript gives a cost overview of compensation payments for large carnivore damages across Europe (27 countries). The costs are presented separately for bears, wolves, wolverine and lynx and analysed in relation to husbandry practice, whether the large carnivore has been reintroduced/recolonized the country, whether compensation costs is dependent upon the use of preventative measures and the economic wealth of the country.

I found the way of presentation very clear and intuitive, essentially, the candidate was able to put a price tag on having large carnivores in a country. This price tag amounted to 6300€ for a wolverine, 2400€ for a wolf, 1800€ per bear, and 700€ per lynx. The presentation how different drivers affect costs is also clear and concise.

The supplementary material is very informative. I find it extremely important to provide raw data wherever possible, for e.g., study replication in a few years since the increase in large carnivore population size is still ongoing in many places. For example, the wolf population in Germany was estimated at 48 individuals for this study but in the meantime has increased to around 1800 individuals. With it of course the number of damages has increased sharply. While the annual compensation cost was estimated to be 25000€ for this study (500€ per individual), this has increased to 800000€ in 2020 (see https://www.dbb-wolf.de/wolfsmanagement/herdenschutz/praeventions-_und_ausgleichszahlungen, with a similar 450€ per individual). On top of that however comes an additional 9,000,000€ of prevention costs which would ramp up the cost per individual wolf to 5,450€. I picked just this one example because I found the information collated for this study very interesting and I fully endorse the authors call for a standardized European database for damage claims and compensation cost. However, based on this example I wonder whether a deeper discussion into population sizes and future increases in large carnivore population sizes and their acceptance in the public would be useful. Given that wolves for example tend to have a hyper-exponential population growth, the numbers in your study will be and are “outdated” very quickly. With increases in population size after recolonization or reintroduction the compensation system probably also adapts. In the wolf example, additional expenses for preventative measures are payed by the government which increase the cost from 500€ per individual to almost 5,500€. The second part of the paper discusses costs for preventative measures and I will come to that in a moment. Further minor comments to the first part of the paper are:

- The currency used, i.e., purchasing power parity (PPS) was not quite clear to me and how it is calculated was only presented in the supplementary material, I think this could have been explained better.
- I really liked Figure 1, but I wonder if the colour scheme of the legend could have been chosen in smaller increments. For example, in the wolf map – the majority of countries/populations are in the 1000 – 10000 category but it is unclear if therein there are further still huge discrepancies (looking at the table in the supplements there are).
- You state that 66% of all compensation cost in Europe went to Sami reindeer herders or free-ranging sheep in Norway. This is huge number, meaning that the other 25 European countries together only pay for 34% of the total compensation costs. It was not stated or discussed in the main text whether the time scales over which the data were collected were comparable across countries.

As a second additional analysis, the candidate focused on the cost of brown bear damage prevention measures. He found that prevention measures where more costly

than compensation payments, on average twice as costly. However, the range was extreme where France invested about 15x as much money into prevention than it payed for compensation. There was no relationship between compensation and investment in prevention. This part of the paper was very informative, I would be curious to see these numbers for the other three species but the wealth of information in this paper is already impressive. After I would however argue that the cost of having large carnivores (i.e., the 6300€ for a wolverine, 2400€ for a wolf, 1800€ per bear, and 700€ per lynx) should eventually be recalculated with taking expenses for prevention into account. Especially for countries with high investments in prevention (such as France in the case of bears or more recently apparently also Germany in the case of wolves) the true cost of having carnivores might be substantially higher than the stated numbers.

Even though it might be beyond the scope of this paper I would have liked to read more about problems or proper implementation of protection measures. The candidate hinted to dead batteries for electric fences or chained dogs but also the acceptance of the preventative measures may be low in places where they haven't been implemented traditionally - fencing is not considered an option in Norway or on alpine pastures in the alps and guarding dogs are seen controverse especially in areas that are also used for human recreation.

Chapter 3 - Spatial ecology of conflicts: unravelling patterns of wildlife damage at multiple scales, published in Proceedings of the Royal Society B

In the second paper (third chapter) the candidate takes a spatial modelling approach at explaining damage risk by brown bears. The unique aspect of this study is that the candidate models risk at three spatial scales - the landscape scale (5x5 km), local scale (1x1 km) and the household scale (point data, i.e., no extrapolation). The prediction is that the likelihood that apiaries are damaged will be affected differently at the three scales and that only in combination we can fully understand the risk. For example – the risk at the household scale will additionally be conditional on the risk at the higher scales.
The response variable for all three models was binary – damage has been recorded versus no damage has been recorded.
At the landscape scale, damage probability was modelled simply a function of bear and apiary presence – in isolation, i.e., where only bears occur but no apiaries and vice versa – no conflicts are expected, whereas in areas where both bears and apiaries occur, conflicts are possible.
At the local scale, common landscape variables such as road density, human density, terrain and habitat (forest versus agriculture) were entered as predictors for the likelihood of bear damage.
At the household scale even finer descriptors such as density to the nearest building or forest edge were entered.
Predictive capacity of models was properly assessed and interpreted using AUC.
This complex analysis is a thorough approach to modelling damage risk spatially which can be used as a real tool to decrease damages in the future.
The landscape scale (i.e., general presence of apiaries and bears) was more important in moderating the likelihood of damage at the household scale than the local scale. Covariates used at the local scale were those that are typically used in third order habitat selection models, i.e., at the within home range scale. Deterring features within a bear´s home range (such as major roads or houses) seem to some extent function as an anthropogenic barrier to damage. This is a great finding.

- I missed some details on whether the relationship between number of houses and risk was additive or whether there was an interaction between risk and houses explaining probability of damage best (Figure 4). Also, I missed confidence intervals around the prediction lines.

- The discussion could have featured some specific recommendations for farmers in at risk areas – such as placing beehives ideally close to villages with > 18 houses, less than x% forest cover in a 200m radius and a minimum of x meters away from a forest edge. To some extent I found some information on that but given the many different analysis and results, including the prevention model, for me a very short and integrative summary was missing.
- Out of curiosity I was wondering how you dealt with repeated damages at the same apiary. Did you have data on how often an apiary was damaged and could there be a way of integrating this into a follow up analysis.
- Do you think that some individuals (bears) are disproportionally responsible for the damages? Do you have an idea how one could about designing a study to asses inter-individual variation in using apiaries as a food resource?

Chapter 4 - RESOURCE PULSES AND HUMAN-WILDLIFE CONFLICTS: LINKING SATELLITE INDICATORS AND GROUND DATA ON FOREST PRODUCTIVITY TO PREDICT BROWN BEAR DAMAGES, submitted

The third manuscript of the thesis evaluates how interannual variation in beechnut production affects interannual variation in bear damages. The candidate uses weather and remote sensing data to model beechnut production. Most excitingly, in my opinion, the candidate demonstrates a link between masting and remotely sensed vegetation productivity (i.e. "greenness") in the previous year and summer. These two variables likely have the highest likelihood to be used as a predictive tool for masting as they are easily accessible and processed. In the manuscript a link between mast failure and increased bear damaged is demonstrated. Since the manuscript has not been published yet I am providing more comments that might help revise the manuscript.

Comments

- You say that many wild species rely to some extent on anthropogenic food resources – I would argue that if the population truly relies on anthropogenic foods then either the habitat is not suitable support the species, or the population size. I would rather think that anthropogenic foods are of high caloric value and are often easily obtained – species may therefore use such foods or even become reliant on them but not because there are not enough natural foods but because they are easily accessible
- The idea to use NDVI as a measure of mast seeding is interesting but I was missing an explanation of how this would work. NDVI is an indicator of primary productivity, i.e., "greenness" – would you expect that in a year of mast seeding, trees show other physiological changes that may lead to lower or higher primary productivity? Based on your discussion there are some hypotheses our there which predict such a relationship and I would have introduced these already here in the introduction.
- I was missing a broader introduction of the study system. In particular, as I understand it, bilberries are another important food resource for bears in the Carpathians, which also is a masting species. Further, you mention the use of anthropogenic food resources such as apiaries but what about supplementary feeding sites which are arguably also anthropogenic but are food piles easily available for bears. Is there fluctuation in the abundance of the latter over the years?
- How could you test which other resources become most important for bears in years of beechnut crop failure? Though damaged indeed increased I would argue that the combined increase in damages would not offset a bears´ caloric loss through the beechnut crop failure – other resources will probably mostly supplement for beechnuts.
- You show that the maximum number of damages occurs in July – not during hibernation, how would you explain this?
- Your best model has a marginal R2 of 0.05 - 0.32 (and a conditional R2 of 0.71 – 0.75 with plotID and year as random effects?), it would be interesting if the model performs ok when predicting outside the range of the data, i.e., in the upcoming years. Given the

relatively low marginal square that could be challenging. In Table 2 you report AICc values but it would have been more interesting to see the relative contribution of each predictor to explaining beechnut masting, such a partitioning can be achieved using the package partR2.

- I find it very interesting that low primary productivity in summer hinted towards a masting year, this finding could indeed and most easily be used to predict a masting year, albeit on a very short time scale
- I would like to key in on the berry picking control – would you mind elaborating a bit how intense the "berry picking pressure" is in your study area, i.e. is there any commercial picking? I presume that berry picking is mostly concentrated close to roads that facilitate access to the forest, if bears avoid roads and there are enough refugia that are farther away from roads, would you expect that bears and people can effectively share berries as a resource? I agree that if both berries and beechmast fail in the same year, the situation might be more precarious.
- Are berries and beechmast available at approximately the same time? I presume that beechmast would be available for longer while ripe berries are quickly turning overripe and fall from the bush – a short discussion on the temporal sequence of berry and beechnut fruiting would have been good.
- I wonder if beechnut production in lag 1 could be coded as a three-level factor – mast, average or failure. Currently, the negative effect is a bit puzzling since when the previous year was a failure or average we should conversely expect a higher likelihood of a mast year.

General comment

I was surprised to not find a general discussion at the end of the thesis as I would have liked to see how the candidate sets the results of the three independent chapters into relation with each other, however since it is missing from the thesis, I presume it is not a formal requirement.

Conclusion

I conclude that the dissertation of Mr Carlos Bautista Leon, M.Sc. fulfils with great excess all the requirements for a doctoral dissertation by the Act on Scientific Degrees and Academic Title and on Degrees and Title in Art (Article 13 of the Act of 14 March 2003 as amended - consolidated text: Journal of Laws 2017, item 1789) on the basis of the Act Introducing the Act - Law on Higher Education and Science (Article 179, paragraph 1 of the Act of 3 July 2018, Journal of Laws 2018, item 1669). The doctoral student presented a high level of theoretical knowledge, a high level of scientific workshop and knowledge of various research methods, which proves his scientific maturity and ability to conduct research independently. Therefore, I request the Scientific Council of the Institute of Nature Conservation of the Polish Academy of Sciences in Cracow to admit him to further stages of the doctoral program.