

Dear Editor,

We sincerely thank you and the Reviewers for the positive and helpful comments and suggestions on the manuscript. We have attempted to follow or answer them meticulously and greatly look forward to your judgment.

Mellina Sidous, on behalf of all authors.

Review 1 : Eli Strauss

A major goal of wildlife conservation and management is to predict population changes of wild animals. This study investigates how pulses of large megaherbivore (elephant) carcasses modifies predator-prey population dynamics using a long-term study of spotted hyena and ungulate observations at waterholes. They find no evidence that hyena or ungulate population growth changes as a result of increases in elephant carcasses.

The paper uses an impressive ecological dataset and aims for an ambitious question of broad relevance. Although some aspects of the writing throughout the paper sometimes reduced clarity, I found that overall the ideas of the paper were well thought-out and communicated. The statistical approach was clearly explained, justified, and appropriate to the data. I have a few small suggestions for improvement.

Thank you very much for this very positive feedback on our work.

Major comments

- **I would have liked to have learned more about the water supplementation policy. Given that the observation of hyena and prey animals occurs at watering holes, and some periods have more water availability than others, I'm left wondering if the trends presented in the results have more to do with varying attraction to watering holes over time rather than variation in population size. When there was active water supplementation, did data collectors count prey/hyenas at these new water sources?**

Each year, all waterholes that had water (this was preliminarily determined by flying over the park) were surveyed, irrespective of their nature (pumped or natural) or the date they were created. To control for the changes in attraction induced either by water being exceptionally held in natural pans in rainy years or by the creation of new waterholes, we grouped waterholes that were close in new spatial units centred on consistent pumped waterholes using Voronoi tessellation. The rationale behind this idea is that, if a permanent waterhole loses attraction because another waterhole was created nearby, then grouping the two waterholes into one single spatial unit that has its own attraction would reduce the bias. We have clarified this in text in the method section when Voronoi tessellation was explained (lines 147-158 of the revised manuscript).

- **Can the authors explain why the model with constant growth rate consistently predicted lower densities of both hyenas and prey than the other two models across the entire study period (Figure 3)? Does this make sense, or could this reflect an issue with one or more of these models?**

The reason why constant models consistently predict lower densities for both hyaena and prey is because the models are more constrained than the two others. Variance of the time varying and period models are less constraining and allow densities to vary more from one time step to another (in other word, they are less stable). This allows densities to greatly increase between two-time steps, such that even subsequent decreases do not reduce the population densities as much as the constant model, for which the population never grow strongly. In addition, growth rate estimated from constant models are lower in average than the time varying and the period models. Indeed, although densities fluctuated during the time period, it appears that there was no net growth in density from 1972 to 2020 and this may explain the low values estimated for the parameter in the constant models that only estimates one growth rate for the whole period.

More precisely, for hyaena constant model's growth rate (0.054, IC: -0.009; 1.122) is always lower than for the time varying ($\mu = 0.019$, $\sigma = 0.909$) and the period model ($\mu = 0.066$, $\sigma = 0.009$) in average. For herbivores, the growth rate estimated by the constant model is also low (5.58×10^{-5} ; IC: -0.0275; 0.0276) and lower than the mean estimated growth rate in the period model ($\mu = 0.006$, $\sigma = 0.002$) and is not lower than the mean of the growth rate estimated by the time varying model ($\mu = -0.00673$, $\sigma = 0.2418$), but still estimates lower densities as the latter models have a high variability in the estimated growth rate that allow densities to greatly increase on some years.

If requested by the reviewer/ editor we can include these details in the results section or in the appendix. (we would rather not included it, as we discuss mainly the results of the period models in the manuscript).

- **“Lastly, I found the interpretation of the results to be overly strong. In the discussion, the authors state “we do not detect patterns supporting effects of high carcass availability on the population dynamics of hyena and its prey” and I think this nicely summarizes what they found. However, elsewhere—including the title—the authors interpret this absence of evidence as evidence of absence. Given the messiness of the data and the sampling regime (one brief yearly count), it seems quite possible that these huge carcasses are influencing hyena predation rates, and thus prey demography, but that this effect is small or subtle enough not to be detected. In fact, it’s hard to imagine how these carcasses could really have no effect on prey or predator demography. I recommend that the authors alter the title and amend parts of the discussion to soften the conclusions.”**

We agree with the Reviewer's concern (this is why we have since the beginning discussed the subtle density patterns in the discussion, in line with the possible small effects suggested by the Reviewer here) and have modified the sentences that were too strong on the interpretation in the text and changed the title accordingly.

Now line 295 the sentence is : **“The main result of this study does not allow to conclude that a mechanism of hyper- or hypo-predation interfered with the population dynamics of predators and their prey on the long-term.” (l.287-289 of the revised manuscript)**

When it used to be “The main result of this study suggests that if a mechanism of hyper- or hypo-predation occurred, it did not interfere with the population dynamics of predators and their prey on the long-term”(l. 270 of the previous version)

Minor comments

- **l. 49-51: These sentences are confusing. Don't the authors conclude that there is NO evidence of an effect of management measures on prey and hyena population dynamics? I think there may be a typo here, or at the very least, this needs to be clarified.**

We do not conclude that there is NO effect of management measures on prey and hyaena population dynamics. Our results support that the management measures had an effect, but do not provide support for a strong role of scavenging as hypothesized. Rather we conclude for a role of the increased resource availability to herbivores caused by the management practices.

To be less confusing, we reformulated this section of the abstract as follows: **“Models that allow hyaena and their prey populations' growth rate to vary depending on these four periods contributed significantly to explain variations in their density, which is consistent with an effect of management measures on the population dynamics of hyaena and its prey” (l. 47-50 of the revised manuscript)**

- **l. 50-52: These sentences seem very wishy washy and vague for the abstract. Can the authors streamline this to a more straightforward point?**

We precised what is the bottom-up mechanism we were talking about : predator density being driven by the prey density, itself driven by resource availability (that changes here depending on elephant density and surface water availability).

We went from the sentence “We rather hypothesise a predominance of bottom-up mechanisms, although some subtle patterns could be interpreted as consequences of changes in predation pressures following increases or decreases in scavenging opportunity” (l.50-52 in the previous version)

To “Although our results support a predominant role of bottom-up mechanisms, whereby hyaena density is driven by herbivore density, itself driven by resources availability, some subtle patterns of densities could be interpreted as consequences of changes in predation pressure following changes in scavenging opportunities” **(l.50- 53 of the revised manuscript)**

- **l. 55 “on the long run” should be “in the long run”**

This was changed as suggested, thank you (I.56).

- **Introduction: In this first paragraph, it would be helpful to clarify whether the work cited on lines 75-78 comes to some conclusion about the conditions under which carrion availability would reduce or increase predation pressure. These potential effects are mentioned in the paragraph, but it isn't clear how they relate to the work cited.**

The objective of this sentence was not to provide other examples of hyper-predation or hypo-predation, which are already provided in the preceding sentences, but to illustrate that the interplay between scavenging and predation has not been studied using a demographic approach. We have kept the original sentence in the revised manuscript, but we have:

- (1) added one sentence to explicit the major findings from the studies cited. In the revised manuscript, we have included the following sentence "These previous works globally conclude about an impact of scavenging on predation processes, either through an alteration of prey and predator space use (Cortés-Avizanda et al. 2009b), or through a direct modification of predation rate (Cortés-Avizanda et al. 2009a, Andrén et al. 2011, Fallows et al. 2013, Mellard et al. 2021)." (I. 79-82 of the revised manuscript)
- (2) Included the different references as more examples to illustrate cases of hyper-predation and hypo-predation in the preceding sentences (lines 69-79 of the revised manuscript).

- **I. 81 it would be clearer to just say what the consequences are instead of referring the reader back to the prior sentence**

We apologise as the word "latter" was misused, and could indeed be understood as referring to a prior sentence, which was not the case. We replaced it by the word "associated" (I 86 of the revised manuscript).

- **I. 138-139 I would like the authors to say more here about what this study found. What is the evidence that they reliably reflect actual population changes?**

In the revised version of our manuscript, we now clarify that they compare trends in abundance obtained from counts at waterholes to more traditional methods (here aerial census). We replaced "However, long-term trends reliably reflect actual patterns of abundance changes in populations (Valeix et al. 2008)." by "**However, abundance trends detected with these counts are the same as those obtained with other more traditional methods (aerial census; Valeix et al. 2008), and thus we consider that long-term trends inferred from counts at waterholes reliably reflect actual patterns of abundance changes in populations (as in Valeix et al. 2008).**" (I 144-147 of the revised manuscript)

- **I. 250 - this parenthetical statement is confusing, so I recommend the authors spell out that this is not what they found.**

This was amended accordingly, thank you. The new parenthetical statement is “(i.e. we do not detect that hyaena population is less driven by its live prey in periods of high elephant carcass abundance, as we initially hypothesized” (l. 266-267 of the revised manuscript)

- **Figure 3: What are the faint fluctuating lines in panels A and B? In C and D there are only confidence intervals for the constant model, despite statements in the figure caption that ribbons exist for each model type.**

We have added in the legend that the fluctuating lines in panels A and B represent the median of the observations for each year. For the confidence interval for the time varying and period models, they do exist but are very close to the estimates such that they are not visible; this is now specified in the legend of the figure.

The legend is now: **Top: Observed population densities of prey (A) and hyaena (B). Dots correspond to the densities observed at the spatial units (Voronoi polygons), each colour representing a spatial unit (95% of the data kept for visual clarity). Fluctuating thin lines represent the median of the observed densities each year. Bold line and ribbon represent the smooth of the median and its 95% confidence interval. Bottom: Estimated population densities of prey (C) and hyaena (D). Model estimates are given for the constant, time-varying, and period models. The ribbon represents the 95% of these estimates, but is very close to the estimates for the time-varying and period models. In all panels, the dotted vertical lines delimitate the four study periods; elephant pictogram indicates periods of high elephant carcass availability.**

- **I.327-328 Could the authors explain what they mean by “mortality is likely to be compensatory?”**

We have included a definition of this term : “(meaning that individuals killed by hyaena were weak and likely to have died from other causes, such that population’s total mortality remained unchanged)” (l.344-345 of the revised manuscript)

- **I. 334: I think “as we focused here” should be “as we observed here”**

This was changed as suggested, thank you (l 351 of the revised manuscript).

Review 2 : Anonymous reviewer

This manuscript offers an interesting study of the numerical response of hyena and its common prey species in relation to availability of elephant carrion, using long-time data series from a national park in Zimbabwe. The manuscript is well written and was a pleasure to read. I only have very few minor suggestions of changes.

We thank the Reviewer for his/her very positive feedback on our work.

- **Line 50: Something is missing between those sentences.**

This part of the abstract has been modified following a suggestion of the other Reviewer and the revised abstract should be clearer.

It now reads as follows: “Models that allow hyaena and their prey populations’ growth rate to vary depending on these four periods contributed significantly to explain variations in their density, which is consistent with an effect of management measures on the population dynamics of hyaena and its prey. Although our results support a predominant role of bottom-up mechanisms, whereby hyaena density is driven by herbivore density, itself driven by resources availability, some subtle patterns of densities could be interpreted as consequences of changes in predation pressure following changes in scavenging opportunities.” (I.47-53 of the revised manuscript)

- **Line 86: This sentence can be deleted.**

We deleted this sentence as suggested.