Review of PCI Ecology Manuscript #692

The goal of this paper is to expand the current theoretical understanding of of mechanistic underpinnings of the predator-prey (p-p) abundance power law that was originally identified in the paper by Hatton et al in 2015. By combining analyses of simplified predator-prey ODE systems with agent-based modelling, the authors demonstrate that both (environment-mediated), density-dependence among predators ("top-down"), as well as (the originally-proposed) among prey ("bottom-up") may play a role in generating and modulating the p-p scaling law.

I enjoyed reading this paper. It was concisely written, in reasonably accessible language (but some suggestions below to improve this further). My overall assessment is that this is a technically correct study which provides valuable (heuristic, qualitative) insights that will facilitate further investigation of the p-p power law. My most substantive comments are that ecological metabolic theory (AKA MTE) could be used to better parameterize the modelling and obtain deeper insights. My specific comments follow.

1. End of Abstract could have somewhat more specific conclusions perhaps.

2. Not so sure about the first sentence of the Introduction - biological scaling laws are common!

3. I found the Introduction to be somewhat difficult to follow. In particular, the logic and arguments presented in the 2 middle paragraphs on p2 were hard to follow. Need more precise descriptions of the links between environmental variation, species' differences, and species interactions. Yes, understood that Hatton et al did not consider these very rigorously, but how exactly does the environment impact or relate the the "top-down" vs "bottom-up" mechanisms that are the main focus? The *gedankenexperiment* in Fig 3 does sufficiently clarify things for me at least. There are also little things, like the usage of the acronym ABM without definition.

4. I really don't understand the flow of logic that leads to the statement at the end of the Introduction. If precipitation were a significant co-factor, determining the p-p abundance scaling law, why not include it directly in the allometric analysis? And how does this lead to the conclusion that only top-down explanations are feasible? Also, top-down vs bottom-up need to be defined more clearly up front.

5. Then first para of section 2: what class of phenotypic traits are we talking about here?

6. Eqn 2 - shouldn't there be a gain term here?

7. C/B_1 - please elaborate a bit on how this is a functional response.

8. Not clear what the purpose of the qualifications in the paragraph about $\vec{\rho}$ in the paragraph following Eqns 1-2 is.

9. Eqn 4 - q should be search not catch rate (units of area or volume / time).

10. Eqns 5-6: OK, but not all the elements in $\vec{\sigma}$ would be independent of environmental parameters. This is a slightly pedantic point, but, a in particular, depends on the euclidean (and in principle, also fractal) dimension of the environment for example (Delong and Vasseur, 2013; Pawar et al., 2012). The point about covariance / non-independence of q, r and q is an interesting and I think correct one. But you can clarify that these are metabolically inter-linked. Indeed, a is also linked to the other rate parameters in this way.

11. Following Eqn 7-8: The exponent k merits clearer rationale / derivation.

12. One could argue that the ABM was a bit unnecessary as the preceding analytical model do already provide sufficient insights and demonstrate the potential importance of a combination of top-down and bottom-up regulation. I think using underlying metabolic scaling laws for p-p growth and interaction rates (see citations above) to bound the parameterisations in the ODE models would be more insightful. However, Fig 6 makes for some interesting viewing, and also highlights the fact that convergence to the power law is only expected at higher prey densities. I suggest that the authors elaborate a bit more on this issue.

References

Delong, J. P. and Vasseur, D. a. 2013. Linked exploitation and interference competition drives the variable behavior of a classic predator-prey system. – Oikos 122: 1393–1400.

Pawar, S., Dell, A. I. and Van M. Savage 2012. Dimensionality of consumer search space drives trophic interaction strengths. – Nature 486(7404): 485–489.

Samraat Pawar
Department of Life Sciences, Silwood Park
Imperial College London
May 15, 2024