**Simulations\_description**

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This present document describes the approach we used for the simulations for our study:   
**Samuel Dijoux, Aslak Smalås, Raul Primicerio, David Boukal. Differences in tri-trophic community responses to temperature-dependent vital rates, thermal niche mismatches and temperature-size rule** (under review)**.**

**Preprint version: *Authorea*. July 31, 2024** (DOI: [10.22541/au.172246246.66869214/v1](https://doi.org/10.22541/au.172246246.66869214/v1)). We conducted a set of demographic, equilibrium and co-dimension bifurcation analyses applied to tri-trophic chain, following the PSPManalysis approach described by A.M. de Roos (<https://staff.fnwi.uva.nl/a.m.deroos/PSPManalysis/index.html>).

***Script PSPM\_TPC-TSR\_PSPMequi\_simulations.R***

The script is organized in 5 sections, each implementing different temperature-dependencies in species traits and/or rates. The diversity of scenario highlighted below was possible thanks to switch commands we introduced in the model to specifically consider the influence of a given (or multiple) temperature-dependency at community level and on consumer life histories. The simulations requires the 3 models: *PSPM\_TPC-TSR\_model.R* for most analysis, *PSPM\_TPC-TSR\_Thermal-Mismatch\_model.R* for analyses on species thermal niche mismatch (Section 4), and *PSPM\_TPC-TSR\_Demo\_model.R* for the demographic analyses (Section 5).

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| **Section** | **Implementation to temperature-dependencies** | **Outcomes**  **(Figs and SI)** |
| S1   * S1A * S1B * S1C * S1D * S1E * S1F * S1G * S1H * S1I | Thermal performance curve alone in:   * Consumer rates   + ingestion rate only   + birth rate only   + growth rate only   + metabolic rate   + all rates included * Predator rates   + functional response only   + mortality rate only   + all rates included * Consumer and predator rates | Fig.S3a  Fig.S3b  Fig.S3c  Fig.S3d  Fig.2a  Fig.S3e  Fig.S3f  Fig.2b  Fig.2c |
| S2   * S2A * S2B * S2C * S2D * S2E * S2F * S2G | Temperature-Size Rule alone in:   * a single trait:   + Predation maximum foraging size *Lv*   + Consumer maturation size *Lmat (*as *Lj* in the script*)*   + Consumer asymptotic size *L∞* *(*as *Lm* in the script*)* * a pair of traits   + *Lmat* and *L∞*   + *Lv* and *Lmat*   + *Lv* and *L∞* * all traits (*Lv*, *Lmat* and *L∞*) | Fig.2e; Fig.S4a  Fig.S4b  Fig.S4c  Fig.2d; Fig.S4d  Fig.S4e  Fig.S4f  Fig.2f; Fig.S4g |
| S3   * S3A * S3B * S3C * S3D * S3E * S3F * S3G * S3H * S3I | 3x3 combinations of TPC and TSR   * TPC(Consumer) with   + TSR(Consumer)   + TSR(Predator)   + TSR(Consumer and Predator) * TPC(Predator) with   + TSR(Consumer)   + TSR(Predator)   + TSR(Consumer and Predator) * TPC(Consumer and Predator)   + TSR(Consumer)   + TSR(Predator)   + TSR(Consumer and Predator) | Fig. S5  Fig.2g  Fig.2h  Fig.2i |
| S4   * S4A * S4C * S4B * S4D | Mismatches between Species Thermal Niches (accounting for TSR&TPC in both consumer and predator)   * Focal species: predator, and cold/warm-adapted consumer   + at 20°C   + at 13°C * Focal species: consumer, and cold/warm-adapted predator   + at 20°C   + at 13°C | Fig.3 |
| S5   * S5A-C * S5D-F * S5G * S5H-I * S5J-L * S5M | Consumer life histories under joint influences of TSR and TPC in consumer traits and rates (additionally require the function PSPMdemo from the PSPManalysis package)   * TSR only   + single trait   + two traits   + all traits * TPC + TSR, with TSR implemented in   + a single trait   + two traits   All traits | Figs S6-S8 |

The simulations within each section follow the same approach:

1. Simulations of the successive community transitions at equilibrium across one environmental gradient, i.e temperature *T* or resource productivity (characterized by its carrying capacity *K*). This is done by simulating the community biomass at equilibrium across the gradient when only composed of resource to detect the bifurcation threshold ‘*BP*’ denoting consumer invasion threshold. From this point, we then simulate Consumer-resource equilibrium across the gradient to detect another bifurcation threshold ‘*BPE*’ denoting predator invasion. Finally, we simulate the tri-trophic chain at equilibrium to detect any potential tipping point (also called limit point, denoted as ‘*LP*’ by the package). All dataset and bifurcation points are saved in the *PSPM\_TPC-TSR\_PSPMequi\_data.Rdata*. By default, the environmental temperature is fixed at 20°C and resource productivity at 3·10-4 g.L-1.
2. We then run co-dimension bifurcation analyses of the bifurcation points across both temperature and productivity gradients

For clarity, all simulations are stored and names regarding a nomenclature ***SSS\_GGG\_bp*** with SSS=section as above, GGG= *K*, *T* (for a single gradient), or *KT* for co-dimension analyses involving both gradients, and *bp* refer to the bifurcation points (*BP*, *BPE*) or limit point (*LP*)