Appendix

Appendix A. Model details

Quantitative traits		**Ranges**
x	Consumers niche trait	$[-5;5]$
y	Resources niche trait	$[-5;5]$
z	Consumers foraging trait	$[0;1]$
State variables		**Shapes**
$R(t,y)$	Resource density	see Eq. (1)
$\overline{y}(t)$	Mean resource trait	$\overline{y}(t) = \int y \frac{R(t,y)}{\int R(t,y)dy} dy$
[0.5pt] $C(t,x,z)$	Consumer density with foraging trait z	see Eq. (2)
$\overline{x}(t)$	Mean consumer niche trait	$\overline{x}(t) = \int x \frac{\int C(t,x,z)dz}{\iint C(t,x,z)dxdz} dx$
$\overline{z}(t)$	Mean foraging trait	$\overline{z}(t) = \iint z \frac{C(t,x,z)}{\iint C(t,x,z)dxdz} dxdz$
[0.5pt] $\phi_{RF}(t,y)$	Random Foraging efforts	$\phi_{RF}(t,y) = \frac{R(t,y)}{\int R(t,y)dy}$
$\phi_{PF}(t,x,y,z)$	Relative Foraging efforts	see Eq. (11)
$\phi(t,x,y,z)$	Effective Foraging efforts	$\phi = z\phi_{PF} + (1-z)\phi_{RF}$
Functional responses		**Shapes**
$F_R(t,y)$	Resource consumption	$\iint U(t,x,y,z)C(t,x,z)dxdz$
$F_C(t,x,z)$	Resource absorption	$\alpha \int U(t,x,y,z)R(t,y)dy$
$U(t,x,y,z)$	resource uptake per consumer	see Eq. (6)
$K(y)$	Carrying capacity	$K(y) = K_0 e^{-\frac{y^2}{2\sigma_K^2}}$
$K_e(y)$	Competition strength	$K_e(y) = e^{-\frac{y^2}{2\sigma_C^2}}$
$r_e(t,y)$	Effective resource density	see Eq. (4)
$\Delta(x,y)$	Interaction strength between resources and consumers	$\Delta(x,y) = \frac{e^{-\frac{(x-y)^2}{2\sigma^2}}}{\sqrt{2\pi\sigma^2}}$
$u(t,x,y,z)$	Potential resource uptake of a consumer	see Eq. (12)
$s(z)$	Searching time	$s(z) = s_{min} + z(s_{max} - s_{min})$
[0.5pt] $\mathcal{M}_R(t,y)$	Resource niche trait mutations	see Eq. (8)
$\mathcal{M}_C(t,x,z)$	Consumer trait mutations	see Eq. (8)
Aggregate properties		**Shapes**
$FDis_R(t)$	Functional dispersion of resources	$FDis_R(t) = \int \frac{\lvert y-\overline{y}(t)\rvert R(t,y)}{\int R(t,y)dy} dy$
$FDis_C(t)$	Functional dispersion of consumers	$FDis_C(t) = \int \frac{\lvert x-\overline{x}(t)\rvert \int C(t,x,z)dz}{\iint C(t,x,z)ddxz} dx$
$Prod$	Productivity	$Prod = \iint C(T,x,z)F_C(T,x,z)\, dx\, dz$
ρ_{ij}	Niche overlap between foraging traits	see Eq.(16)
$FM(t)$	Functional match	see Eq.(17)

Table SI.1 – List of the quantitative traits subject to evolutionary change, the state variables, the functions and the aggregate system-level properties involved the model.

A.1. Stationary regime

The stationary regime is visible in this simulation of the emergence of a community in which plastic foraging evolves: `https://drive.google.com/`. The system follows a perpetual turnover of resources and consumers densities in function of their niche and foraging traits, but the macroscopic criteria of the community (exemplified here by the functional diversity *FDis*) reach a quasi equilibrium. Top panels: distribution of resources and consumers in function of their niche trait. Middle panels: distribution of consumers in function of their foraging trait (left) and community-level mean foraging trait in function of time (right). Bottom panels: functional diversity *FDis* of resources and consumers. The other community-level characteristics are also stabilized once the stationary regime is reached.

A.2. Effect of a fixed PF trait

Appendix B. Trade-off on mortality

Our model assumes a trade-off between PF and handling time. In this case, an increase of the foraging trait induces an increases of searching handling time, which eventually induces a reduction of the resource absorption rate. More precisely, for a given foraging trait z, an increase δz of the trait reduces the absorption rate as follows

(18)

$$\begin{aligned} F_C(z+\delta z) &= \alpha \frac{b\int\phi(y)\Delta(x,y)R(y)dy}{1+s(z+\delta z)b\int\phi(y)\Delta(x,y)R(y)} \\ &= \alpha \frac{b\int\phi(y)\Delta(x,y)R(y)dy}{1+s(z)b\int\phi(y)\Delta(x,y)R(y)+\delta z(s_{max}-s_{min})b\int\phi(y)\Delta(x,y)R(y)} \\ &\approx \alpha \frac{b\int\phi(y)\Delta(x,y)R(y)dy}{1+s(z)b\int\phi(y)\Delta(x,y)R(y)} - \delta z(s_{max}-s_{min})\alpha\left(\frac{b\int\phi(y)\Delta(x,y)R(y)}{1+s(z)b\int\phi(y)\Delta(x,y)R(y)}\right)^2 \\ &\approx F_C(z) - \delta z(s_{max}-s_{min})\alpha \end{aligned}$$

Thus an increase of foraging trait will reduce the growth rate of the consumers ($F_C - d - I \iint C$) proportionally to the difference of the PF cost ($s_{max} - s_{min}$).

As mentioned in the main text, the model may have assumed different trade-off such as a positive dependence between mortality rate and foraging trait. In this case the mortality rate may take the following form

$$d(z) = d_{min} + z(d_{max} - d_{min}), \quad (19)$$

where d_{min} is the basal mortality rate while d_{max} is the maximal increase of mortality due to PF. In this case, an increase of the foraging trait will increase the mortality rate proportionally to the maximal increment of mortality ($d_{max} - d_{min}$). The growth rate will reduce proportionally to this quantity. We thus see that the effect of the trade–off will have similar consequences on the evolution of the foraging trait.

B.1. Effect of mortality trade-off on community emergence

B.2. Effect of mortality trade-off with a fixed PF trait

Appendix C. Effect of a quartic carrying capacity functions

C.1. Effect of a quartic carrying capacity function on community emergence

C.2. Effect of a quartic carrying capacity function with a fixed PF trait

C.3. Effect of a quartic carrying capacity function with an evolving PF trait

Appendix D. Functional match between resources and consumers

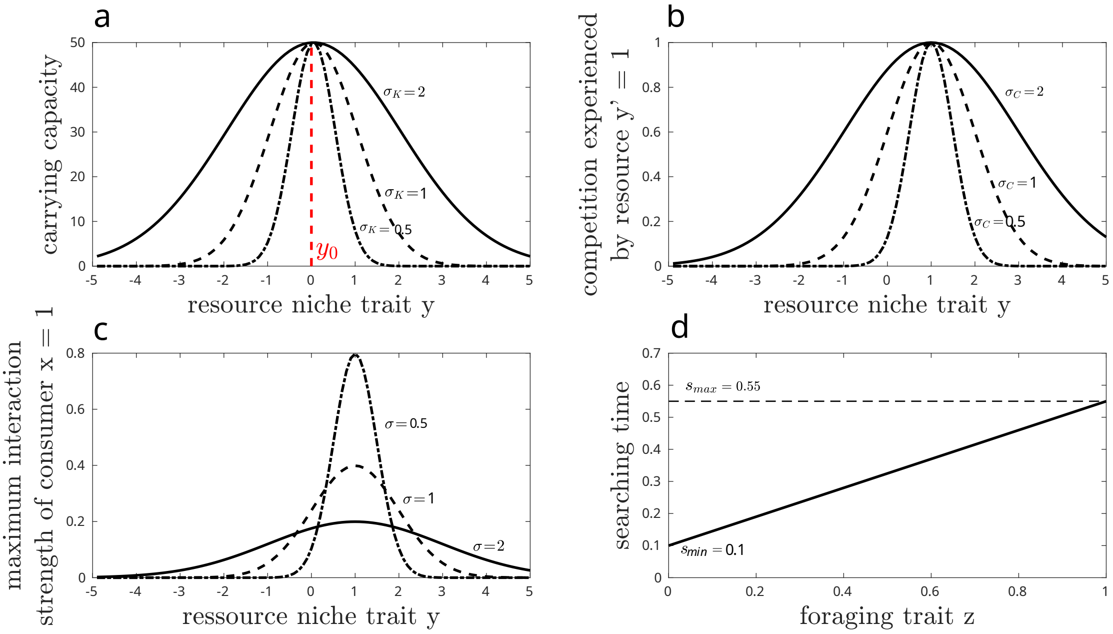

Figure SI.1 – a) Carrying capacity $K(y)$ of resources for various niche width values $\sigma_K = \{0.5, 1, 2\}$. The niche centre fixed at $y_0 = 0$ corresponds to the maximal carrying capacity. b) Competition kernel K_e for various neighbourhood size $\sigma_C = \{0.5, 1, 2\}$ between a focal resource $y' = 1$ and all resources in function of their niche trait y. c) Interactions kernel Δ for various generalization levels ($\sigma = \{0.5, 1, 2\}$) between a focal consumer ($x = 1$) and all the resources in function of their niche trait y. d) Searching time s in function of the foraging trait z. Parameter values as in Table 1.

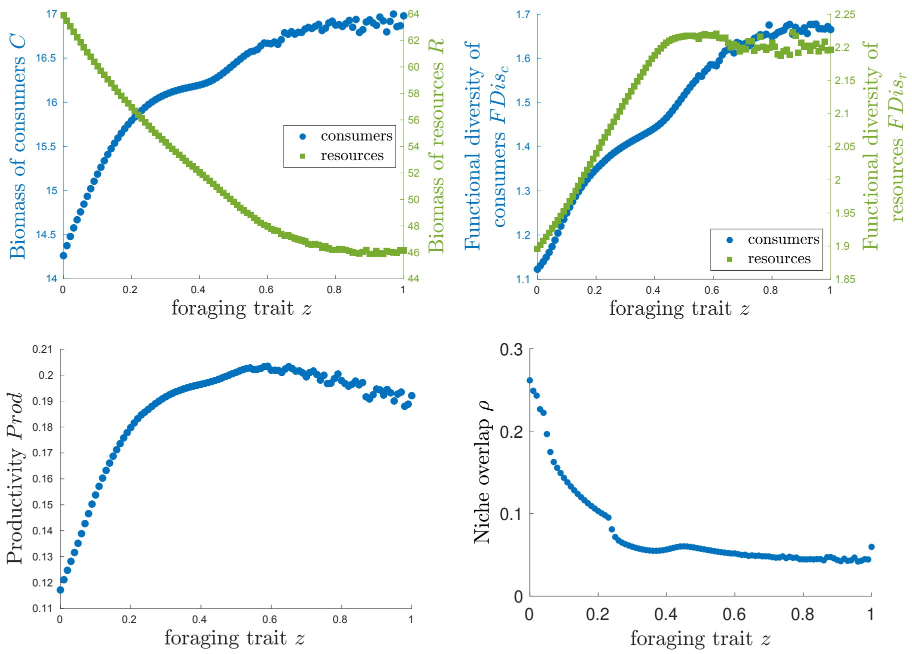

Figure SI.2 – Effect of a fixed foraging trait value z on systems where only the niche traits x and y of resources and consumers can evolve. The measured characteristics are biomass, functional diversity, productivity, and niche overlap.

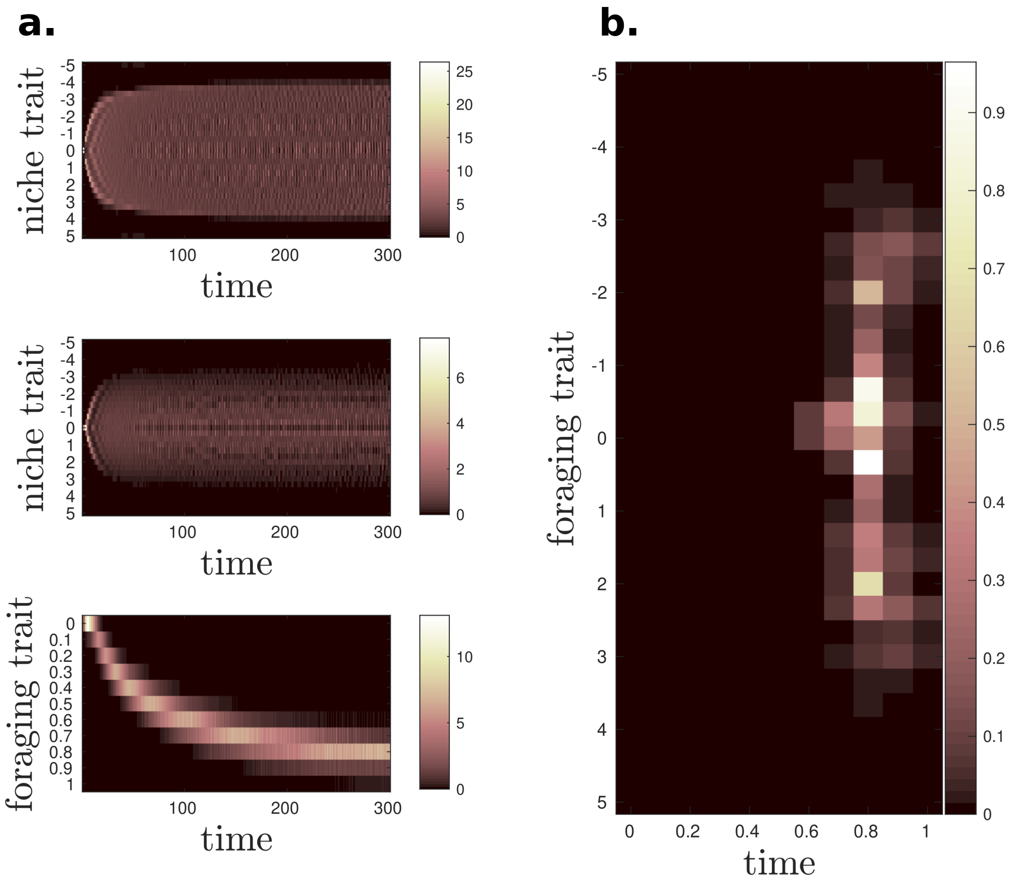

Figure SI.3 – Distribution of resources and consumers over time with a trade-off on mortality. a) Diversification of niche and foraging traits starting from a single resource and consumer at the niche centre, and a RF consumer strategy. Top panel: resource densities $R(t, y)$. Middle panel: consumer densities $\int C(t, x, z)dz$. Bottom panel: foraging trait $\int C(t, x, z)dx$. b) The trait distribution of consumers at steady state (1000 time steps).

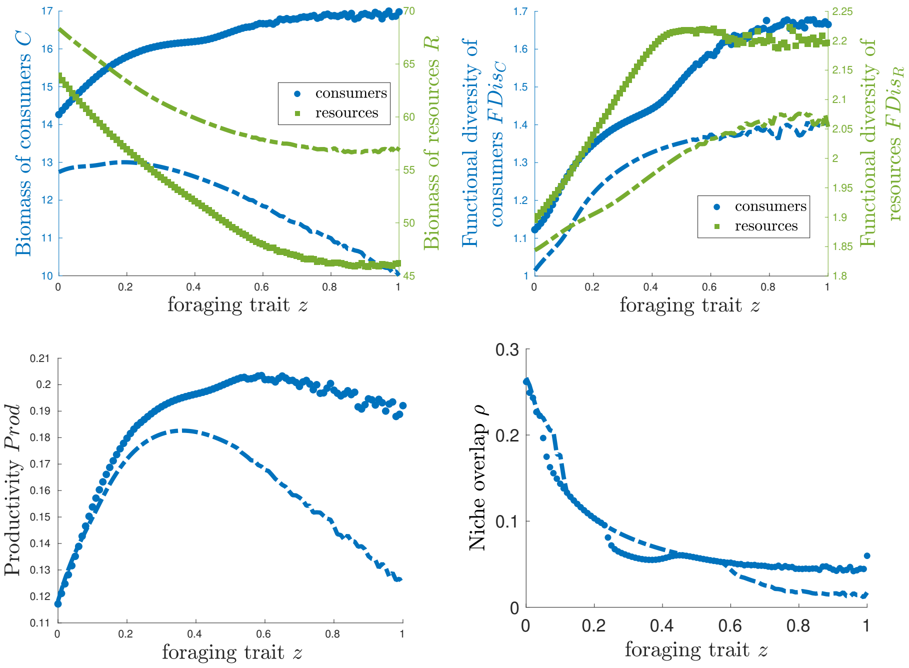

Figure SI.4 – Effect of different mortality trade-off with a fixed foraging trait value z on systems where only the niche traits x and y of resources and consumers can evolve. We compare two mortality trade-off, between PF and: handling time (dotted markers), and mortality rate (dashed curves). The measured characteristics are biomass, functional diversity, productivity, and niche overlap.

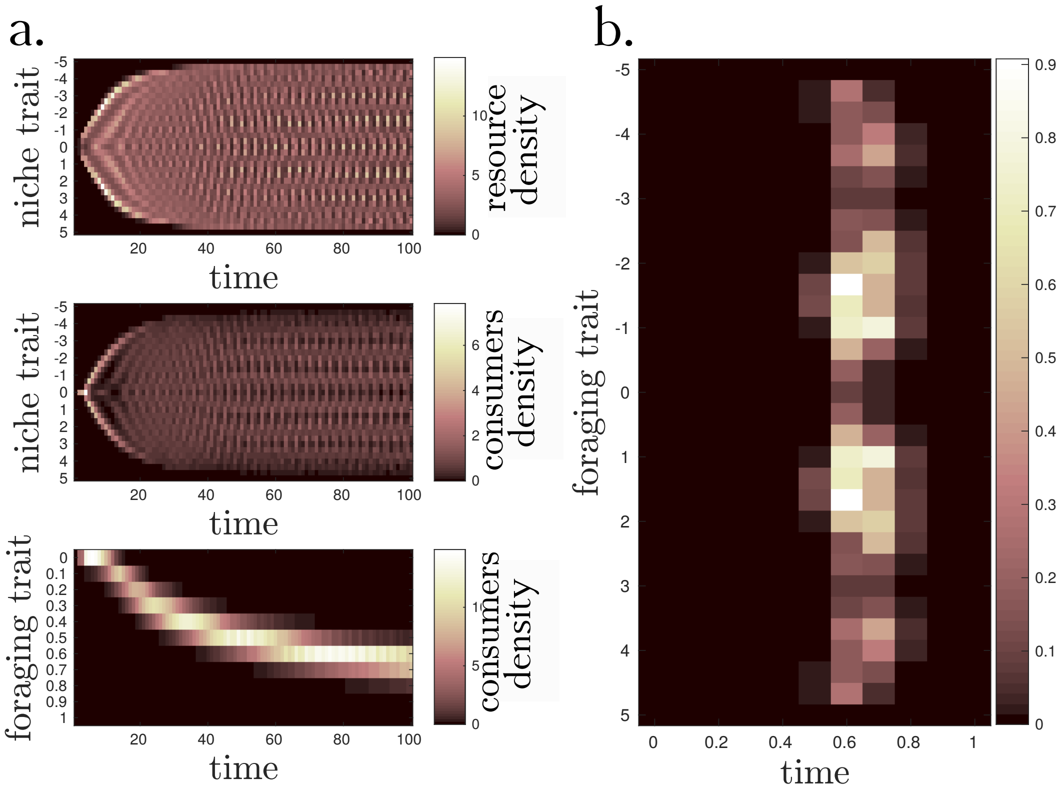

Figure SI.5 – Distribution of resources and consumers over time with a quartic carrying capacity function $K(y) = K_0 \exp\big(-y^4/(12\sigma_K^4)\big)$. a) Diversification of niche and foraging traits starting from a single resource and consumer at the niche centre, and a RF consumer strategy. Top panel: resource densities $R(t,y)$. Middle panel: consumer densities $\int C(t,x,z)dz$. Bottom panel: foraging trait $\int C(t,x,z)dx$. b) The trait distribution of consumers at steady state (1000 time steps).

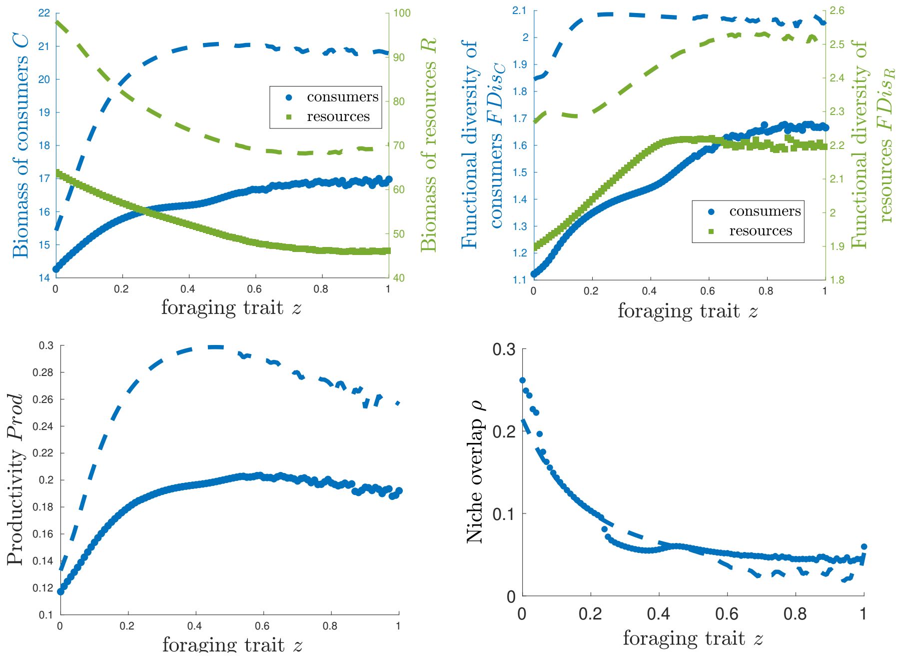

Figure SI.6 – Effect of the carrying capacity kernel K with a fixed foraging trait value z on systems where only the niche traits x and y of resources and consumers can evolve. We compare two carrying capacity function: Gaussian function $K(y) = K_0 \exp\left(-y^2/(2\sigma_K^2)\right)$ (dotted markers) and Quartic function $K(y) = K_0 \exp\left(-y^4/(12\sigma_K^4)\right)$ (dashed curves). The measured characteristics are biomass, functional diversity, productivity, and niche overlap.

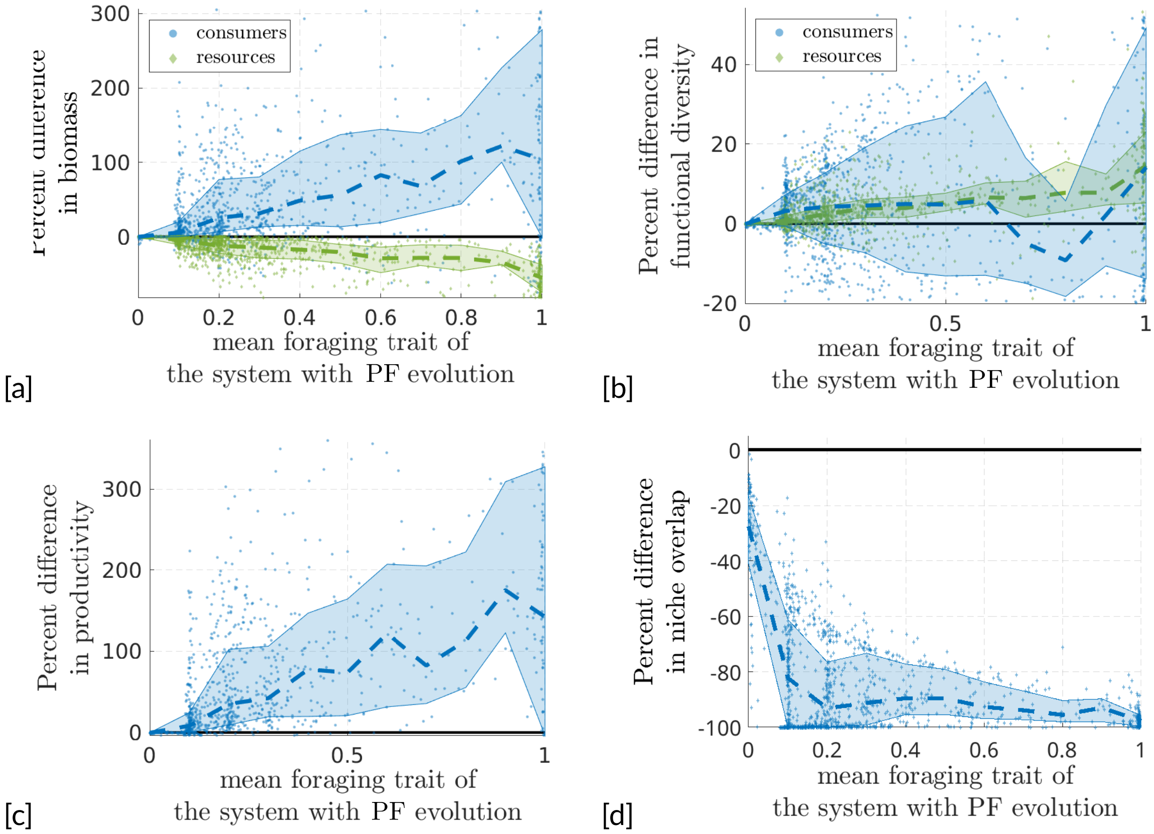

Figure SI.7 – Difference (in %) between systems with PF evolution and fixed RF with a quartic carrying capacity function $K(y) = K_0 \exp\left(-y^4/(12\sigma_K^4)\right)$, for (a) biomass, (b) functional dispersion, (c) productivity, and (d) niche overlap. For each panel, 1500 simulations of 1000 time steps with PF evolution were compared to simulations with fixed RF, the parameters being randomly sampled in the ranges specified in Table 1. Dashed lines: median; areas: 75% confidence intervals.

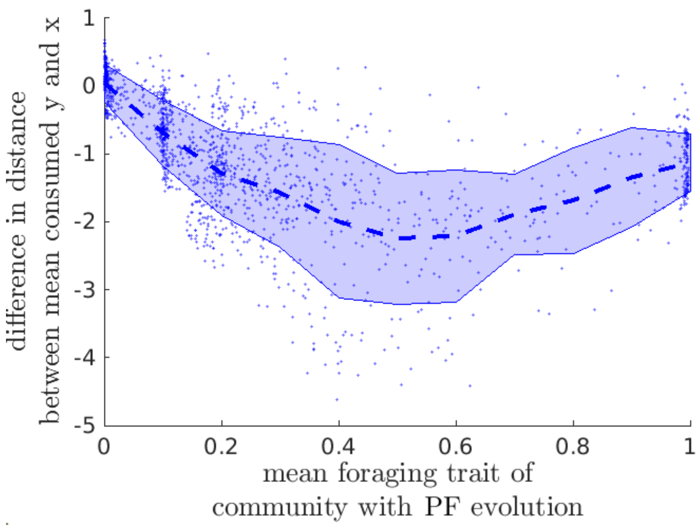

Figure SI.8 – Difference in functional matching between systems with PF evolution and systems with fixed RF. 500 pairs of systems were compared, each pair having the same parameter set randomly sampled in the ranges specified in Table 1. Dashed lines: median; areas: 75% confidence intervals.