

Supplementary Information

Adaptive foraging behaviour increases vulnerability to climate change

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Supplementary information I: Environmental characteristics

Overall, the different environments considered were characterised by two contrasted levels of productivity, leading to a bimodal distribution.

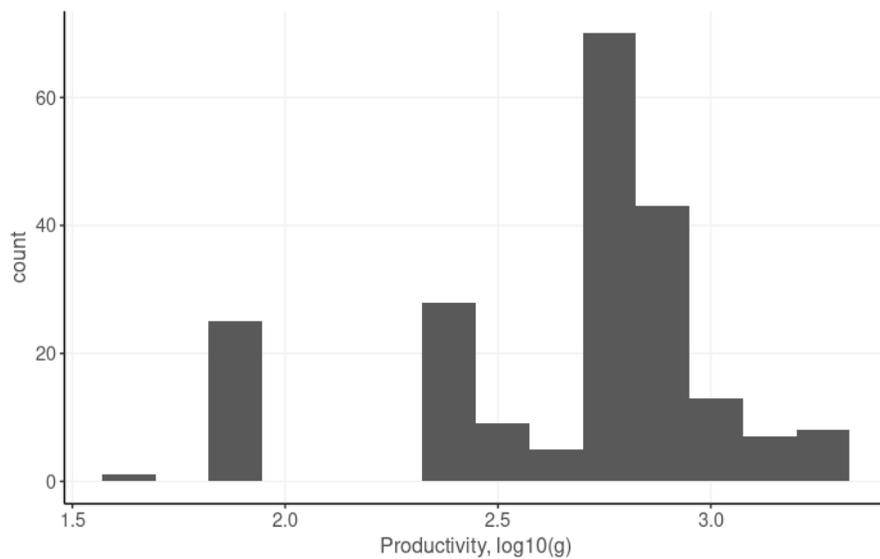


Fig. SI 1.1: distribution of the productivity values (g) for the different environments

Associated to these differences, we observed that the body mass distribution of the basal species (median and standard deviation) was responding differently to temperature depending on productivity values (Figure SI 1.2, Table SI 1.1):

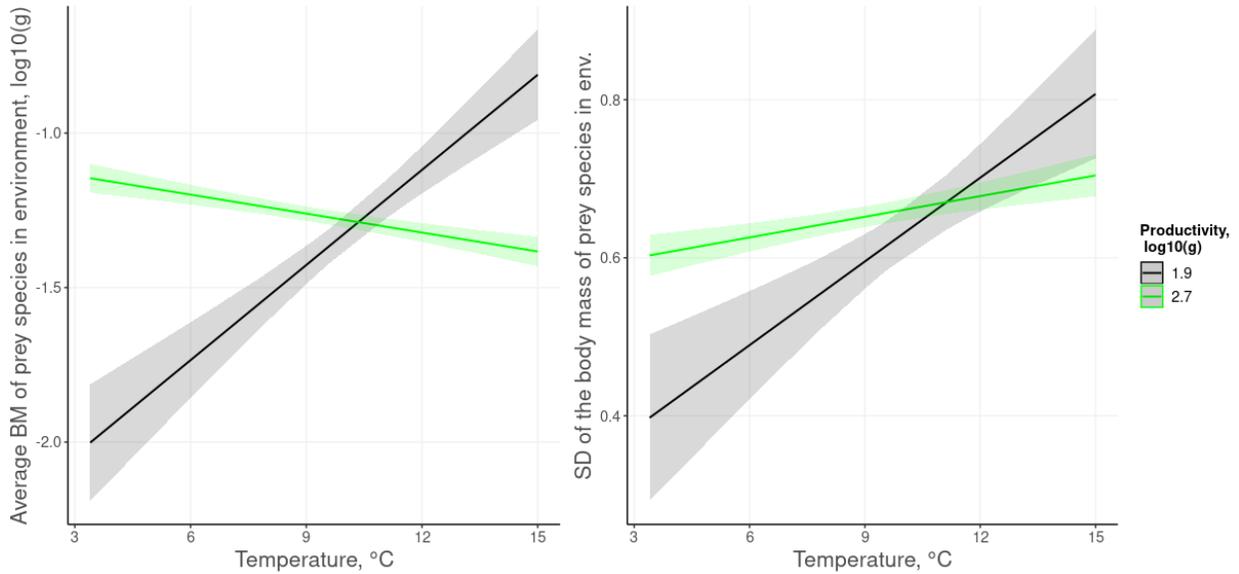


Fig. SI 1.2: response of the body mass structure of the resource species to temperature and productivity

Table SI 1.1: model estimate for the prediction of median and standard deviation of the environment distributions

<i>Predictors</i>	Median of BM			Standard deviation of BM		
	<i>Estimates</i>	<i>CI</i>	<i>p</i>	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	-5.38	-6.32 – -4.43	<0.001	-0.43	-0.95 – 0.10	0.113
Productivity	1.59	1.24 – 1.94	<0.001	0.37	0.17 – 0.57	<0.001
Temperature	0.39	0.30 – 0.49	<0.001	0.10	0.05 – 0.15	<0.001
productivity:temperature	-0.15	-0.19 – -0.12	<0.001	-0.03	-0.05 – -0.01	0.001
Observations	223			223		
R ² / R ² adjusted	0.306 / 0.297			0.160 / 0.148		

Supplementary information II: response of the preferred distribution to temperature at different levels of productivity

As we observed a strong interaction effect between temperature and productivity when explaining the response of the median of the body mass distributions in our different environments, we estimated for which levels of productivity the relationship between temperature and median was significant. At low productivity, we observed a positive slope between the median and temperature albeit not significant. The slope of the regression linearly decreased with productivity value, and became significantly lower than 0 for productivity levels larger than $10^{2.52}$.

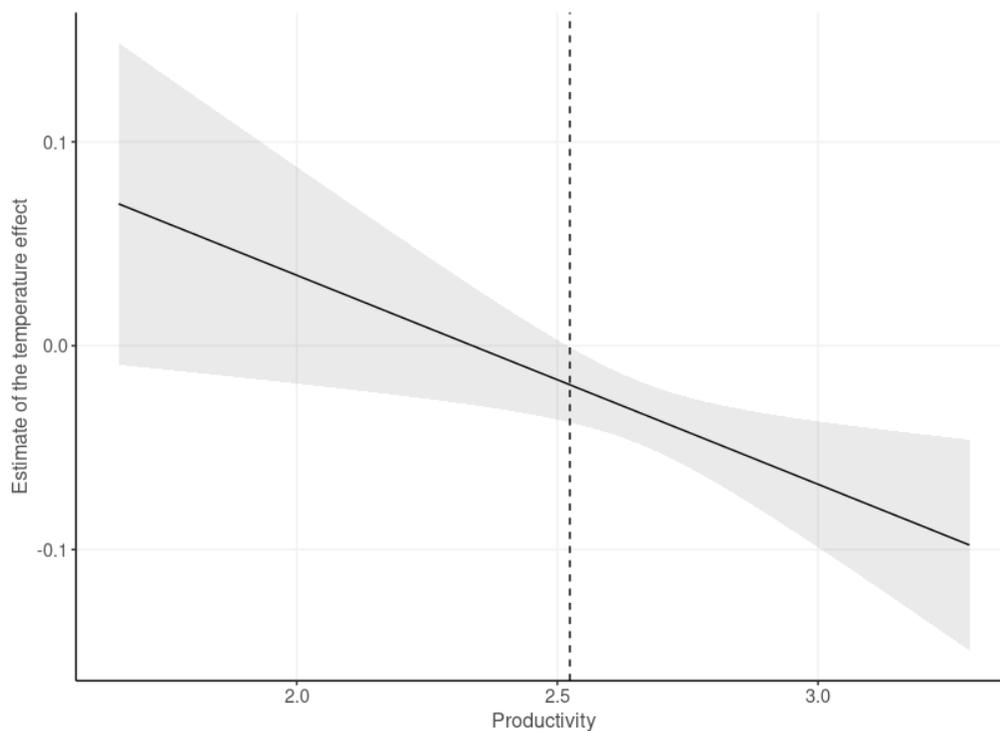


Fig. SI 2.1: Estimate and CI for the temperature effect at different levels of productivity. the dashed line indicates the productivity value above which the temperature effect become significant

Supplementary information III: response of the width of the preferred trophic niche to local conditions

To assess how the width of the preferred niche responded to environmental conditions we fitted the same models as for the median on the standard deviation of the body mass of the preferred distribution. We observed that the standard deviation was decreasing with the predator body mass and with temperature. We however detected an interaction between fish shape and productivity. At low productivity levels the width of the trophic niche of fusiform fish tended to be larger than the one of flat fish while the opposite is observed at higher productivity levels.

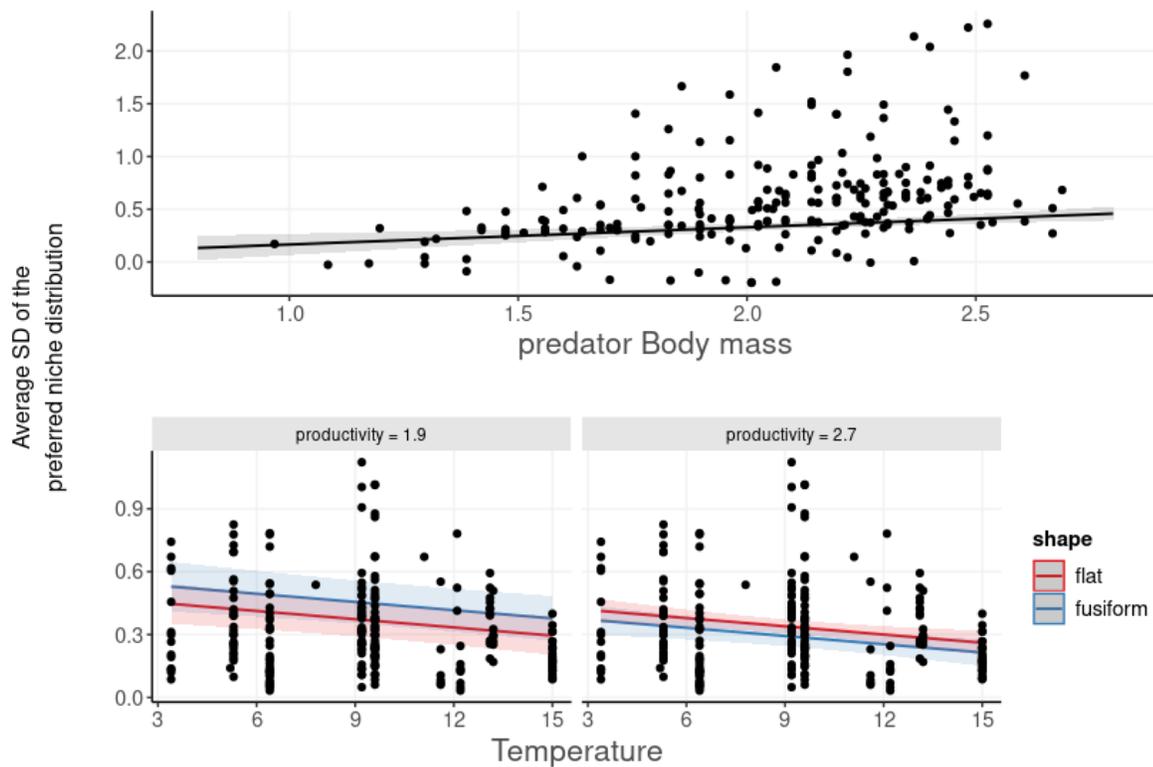


Fig. SI 3.1: Response of the width (standard deviation) of the preferred distribution to predator body mass (a) and temperature for different productivity gradients (b,c). Colours define the fish shape.

Table SI 3.1: model estimates for the prediction of the standard deviation of the preference distributions

<i>Predictors</i>	sd of the preference distribution		
	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	0.238	-0.075 – 0.551	0.135
Predator body mass	0.163	0.078 – 0.247	<0.001
Productivity	-0.043	-0.139 – 0.054	0.384
shapefusiform	0.387	-0.027 – 0.802	0.067
Temperature	-0.013	-0.021 – -0.005	0.001
productivity:shapefusiform	-0.161	-0.314 – -0.007	0.041
Observations	223		
R ² / R ² adjusted	0.137 / 0.118		

Supplementary information IV: Effect of nutrient availability and predators' functional responses type on predictions about species coexistence.

As maximum nutrient availability (variable S_i) and shape of the functional response (q) are not empirically informed, we analysed how sensitive to these two parameters model's predictions are. We varied S_i from 1 to 240 and q from 0 to 0.5. Overall, we observed a very limited effect of nutrient availability on the pattern observed (Fig. SI5.1). The type of the functional response used resulted in more variations on the number of extinctions observed, but did not altered the differences observed due to the incorporation of foraging behaviour (Fig. SI5.2).

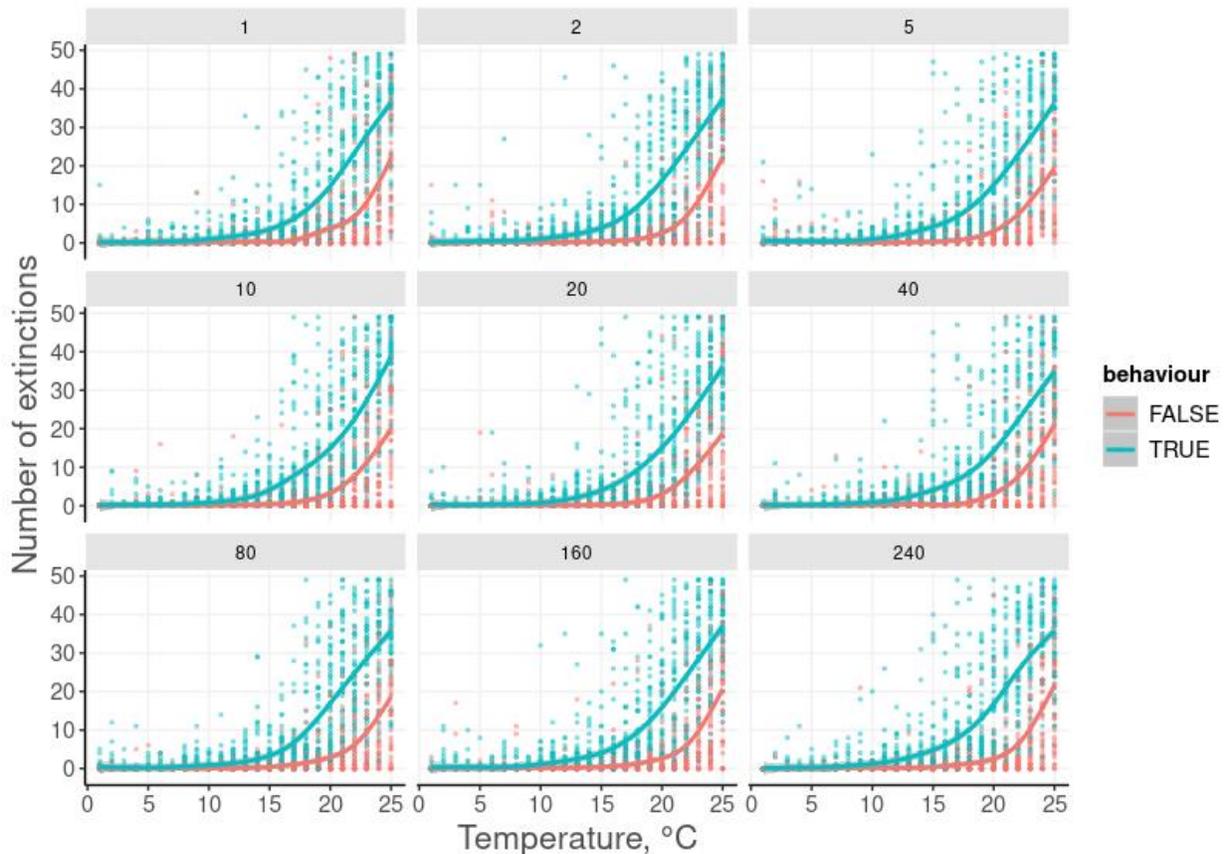


Figure SI 4.1: Effect of different levels of nutrient availability on the number of extinctions predicted by the model. Simulations where ran with a hill exponent (q) of 0.2

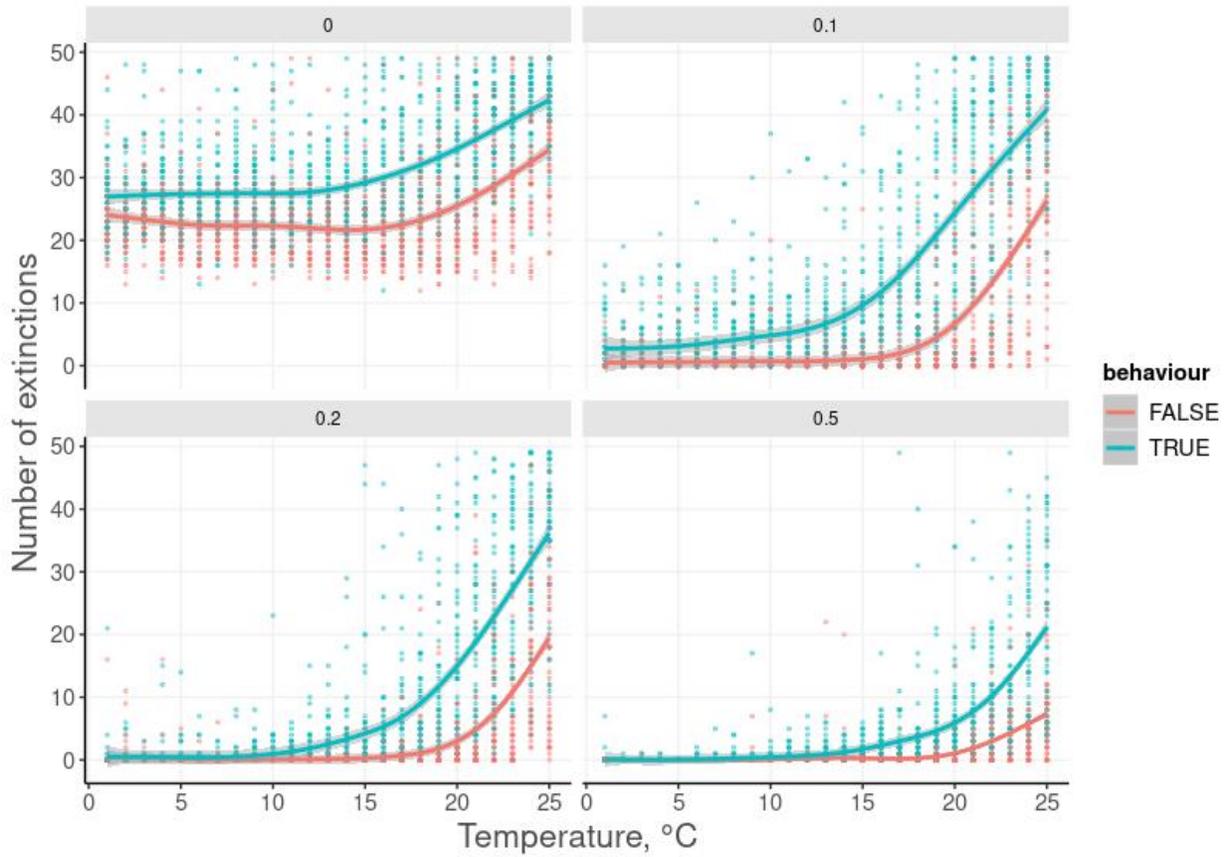


Figure SI4.2: effect of the choice of functional response type on the number of extinctions predicted by the model. Simulations were run for a level of maximum nutrient (S) of 5.

Supplementary information V: Effect of considering different detection probabilities for prey in stomachs

As prey composed of soft tissues only are supposed to be less likely to be detected because of a faster digestion time, we corrected our observation by multiplying the abundance of species with hard body parts by 0.8. This was done to mirror the importance of these species that should persist longer in stomachs. As we are missing a general framework to properly describe how digestion time changes for the different species we used a unique correction factor that is a free parameter in our model (prey are either easy or difficult to digest, Table SI 6.3). We here present the results we would have obtained without using this correction factor.

Results for the realised distributions

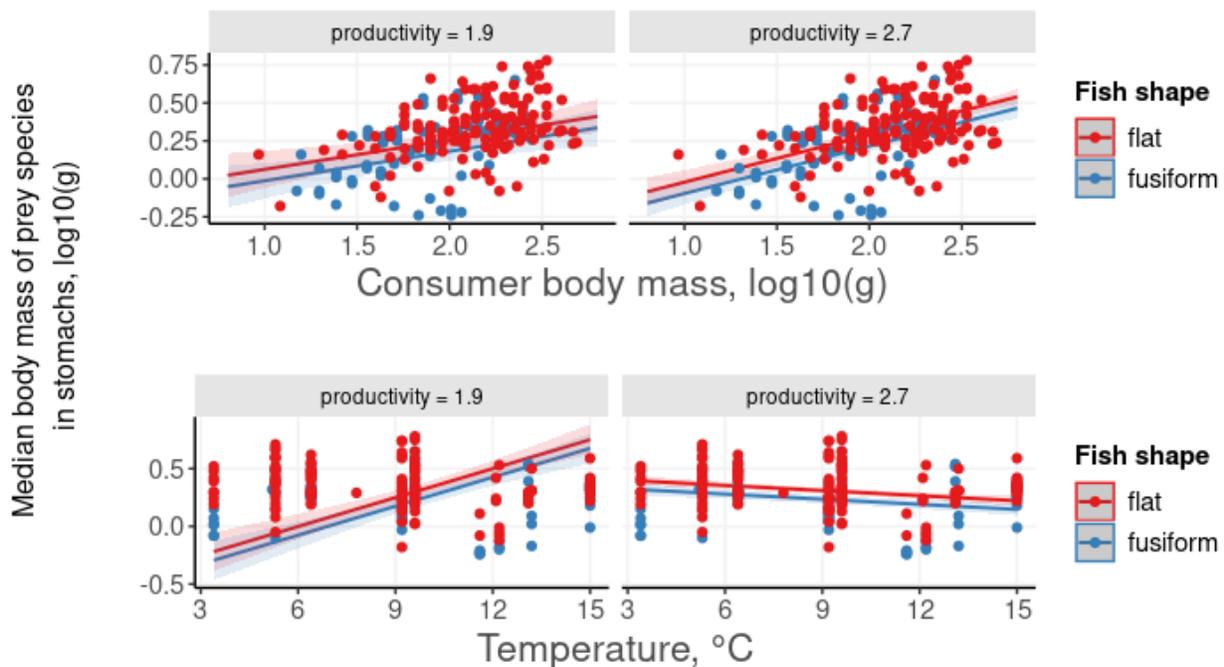


Figure SI5.1: Response of the median body mass of the realised prey body mass distribution to predator body mass (a, b), temperature (c, d) at different productivity levels for the two fish shape. Points represent non-transformed data and lines present model predictions. The shaded areas show the 95% confidence interval on the predicted values. Colours represent the fish functional groups (flat versus fusiforms).

Table SI5.1: response of the realised distribution to predator body mass and environmental gradients

<i>Predictors</i>	Median of the realised distribution		
	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	-2.57	-3.64 - -1.50	<0.001
Predator body mass	-0.09	-0.47 - 0.29	0.649
Productivity	0.88	0.47 - 1.28	<0.001
Shape (fusiform)	-0.08	-0.12 - -0.03	0.001
Temperature	0.32	0.24 - 0.40	<0.001
pred. BM:Productivity	0.15	0.00 - 0.30	0.048
Productivity:Temperature	-0.12	-0.15 - -0.09	<0.001
Observations	224		
R ² / R ² adjusted	0.450 / 0.435		

We can observe that the absence of correction factor does not qualitatively change the trends observed for the realised distributions. The variables selected by the AIC criteria are the same when correction for detectability was used. We can only detect slight changes in the model estimates.

Response of the preference distribution

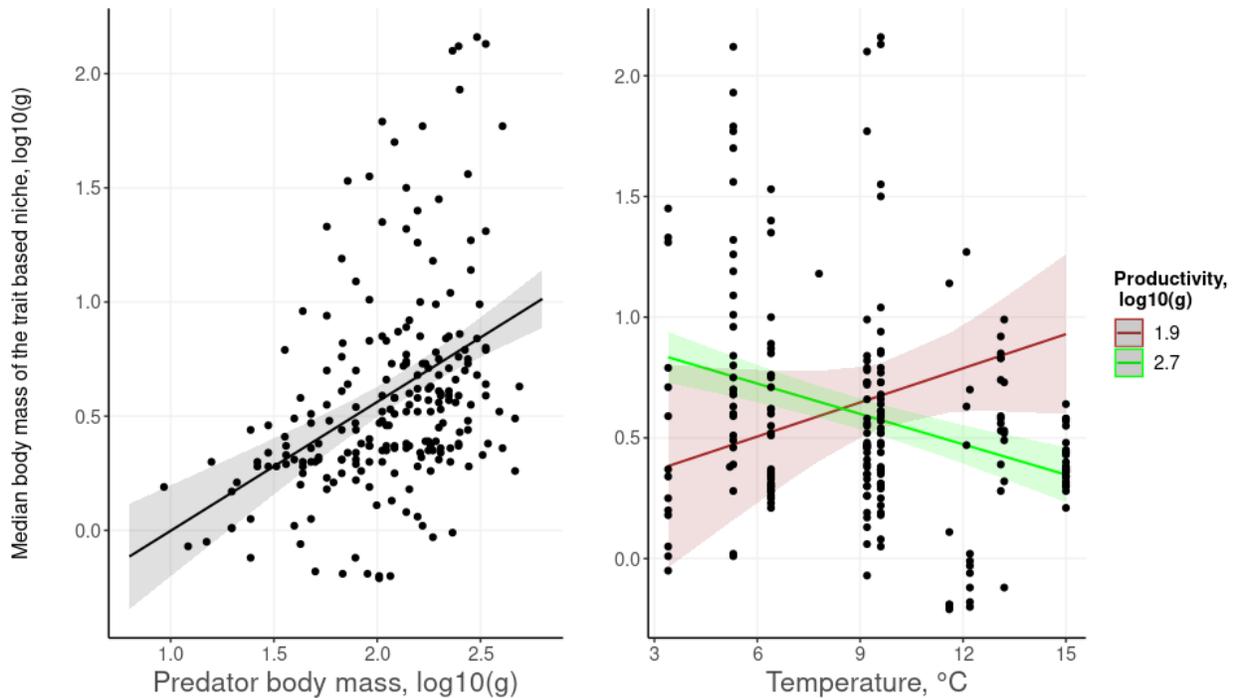


Figure SI5.2: Response of the median body mass of the preference distribution to temperature, productivity, and fish body mass. Points represent non-transformed data and lines represent model predictions. The shaded areas show the 95% confidence interval on the predicted values. Grey and green colour represent two different productivity levels at which the temperature effect is represented

Table SI 5.2: response of the preference distribution to predator body mass and environmental gradients

<i>Predictors</i>	Median of the preference distribution		
	<i>Estimates</i>	<i>CI</i>	<i>p</i>
(Intercept)	-1.252	-3.954 - 1.450	0.362
Predator body mass	-0.153	-1.115 - 0.809	0.754
Productivity	0.392	-0.631 - 1.414	0.451
shapefusiform	-0.124	-0.238 - -0.011	0.032
Temperature	0.259	0.051 - 0.466	0.015
pred.BM:productivity	0.268	-0.103 - 0.639	0.156
Productivity:Temperature	-0.111	-0.189 - -0.033	0.005
Observations	224		
R ² / R ² adjusted	0.282 / 0.262		

We observed here a change in the model output. The effects of predator body masses and productivity on the median of the preference distributions are not significant anymore. This is likely due presence of the new significant effect of the interaction between these two variables, as we can observe that the plots remain quite similar (Fig. SIVI.2).

Classification of species' digestibility

Prey species	Class	Digestibility
<i>Abra alba</i>	Bivalvia	Hard
<i>Aloidis gibba</i>	Bivalvia	Hard
<i>Amphicteis gunneri</i>	Polychaeta	Easy
<i>Amphipoda</i> spp.	Malacostraca	Easy
<i>Anaitides</i> spp.	Polychaeta	Easy
<i>Anthozoa</i> spp.	Anthozoa	Easy
<i>Aphia minuta</i>	Actinopterygii	Hard
<i>Aphroditidae</i> spp.	Polychaeta	Easy
<i>Arenicola marina</i>	Polychaeta	Easy
<i>Asciidiacea</i> spp.	Asciidiacea	Easy
<i>Astarte</i> spp.	Bivalvia	Hard
<i>Balanus</i> spp.	Hexanauplia	Hard
<i>Brada villosa</i>	Polychaeta	Easy
<i>Capitella capitata</i>	Polychaeta	Easy
<i>Carcinus maenas</i>	Malacostraca	Hard
<i>Cardium fasciatum</i>	Bivalvia	Hard
<i>Castalia punctata</i>	Polychaeta	Easy
<i>Clupea harengus</i>	Actinopterygii	Hard
<i>Corophium</i> spp.	Malacostraca	Easy
<i>Crangon crangon</i>	Malacostraca	Hard
<i>Cumacea</i> spp.	Malacostraca	Easy
<i>Mysidacea</i> spp.	Malacostraca	Hard
<i>Cyprina islandica</i>	Bivalvia	Hard

Prey species	Class	Digestibility
Diastylis rathkei	Malacostraca	Easy
Disoma multisectosum	Polychaeta	Easy
Euchone papillosa	Polychaeta	Easy
Gastosaccus spinifer	Malacostraca	Hard
Gobiidae spp.	Actinopterygii	Hard
Halicryptus spinolosus	Halicryptomorpha	Hard
Harmothoe imbricata	Polychaeta	Easy
Harmothoe spp.	Polychaeta	Easy
Hyperia galba	Malacostraca	Easy
Idothea spp.	Malacostraca	Hard
Isopoda spp.	Malacostraca	Hard
Limanda limanda	Actinopterygii	Hard
Macoma spp.	Bivalvia	Hard
Metridium senile	Anthozoa	Hard
Microdeutopus sp.	Malacostraca	Easy
Musculus spp.	Bivalvia	Hard
Mya truncata, Mya arenaria	Bivalvia	Hard
Mysis mixta	Malacostraca	Hard
Mytilus edulis	Bivalvia	Hard
Nemertea spp.	Nemertea	Easy
Nephtys spp.	Polychaeta	Easy
Nucula nitida	Bivalvia	Hard
Ophiura albida	Ophiuroidea	Hard
Other Decapoda	Decapoda	Hard
Other Gastropoda	Gastropoda	Hard
Other Polychaeta	Polychaeta	Easy
Pectinaria koreni	Polychaeta	Easy
Phaxas pellucidus	Bivalvia	Hard
Pherusa plumosa	Polychaeta	Easy
Phtisica marina, Caprella	Malacostraca	Easy
Pisces spp.	Actinopterygii	Hard
Pleuronectiformes spp.	Actinopterygii	Hard
Polydora sp.	Polychaeta	Easy
Pomatoschistus minutus	Actinopterygii	Hard

Prey species	Class	Digestibility
Priapulus caudatus	Priapulida	Easy
Saxicava arctica	Bivalvia	Hard
Scoloplos armiger	Polychaeta	Easy
Spionidae spp.	Polychaeta	Easy
Terebellides stroemi	Polychaeta	Easy
Thyonidium pellucidum	Holothuroidea	Hard