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Systematic variation in the temperature dependence of physiological and ecological traits

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To understand the effects of temperature on biological systems, we compile, organize, and analyze a database of 1,072 thermal responses for microbes, plants, and animals. The unprecedented diversity of traits ($n = 112$), species ($n = 309$), body sizes (15 orders of magnitude), and habitats (all major biomes) in our database allows us to quantify novel features of the temperature response of biological traits. In particular, analysis of the rising component of within-species (intraspecific) responses reveals that 87% are fit well by the Boltzmann–Arrhenius model. The mean activation energy for these rises is 0.66 ± 0.05 eV, similar to the reported across-species (interspecific) value of 0.65 eV. However, systematic variation in the distribution of rise activation energies is evident, including previously unrecognized right skewness around a median of 0.55 eV. This skewness exists across levels of organization, taxa, trophic groups, and habitats, and it is partially explained by prey having increased trait performance at lower temperatures relative to predators, suggesting a thermal version of the life-dinner principle—stronger selection on running for your life than running for your dinner. For unimodal responses, habitat (marine, freshwater, and terrestrial) largely explains the mean temperature at which trait values are optimal but not variation around the mean. The distribution of activation energies for trait falls has a mean of 1.15 ± 0.39 eV (significantly higher than rises) and is also right-skewed. Our results highlight generalities and deviations in the thermal response of biological traits and help to provide a basis to predict better how biological systems, from cells to communities, respond to temperature change.

Investigation of the thermal response of diverse biological processes should reveal general mechanisms by which life responds to Earth's complex and rapidly changing thermal landscape (1). General patterns of how temperature affects biological systems can be deduced in at least two ways. First, physiological and ecological traits (e.g., metabolic rate, encounter rate) can be measured for each species at its optimal temperature and plotted together to construct a single curve across species (2, 3). This interspecific approach has been used extensively (2–8), including studies of how climate affects biological systems (8–11). Second, a curve can be constructed by measuring trait values across a range of temperatures for a single species (intraspecific) (12, 13). In both intra- and interspecific cases, each curve can be characterized by its Q_{10} value or activation energy (4, 6). These parameters, along with optimal temperature and response breadth for intraspecific responses, can be contrasted to explore effects of taxa, traits, and habitats. Indeed, for nearly a century, intraspecific studies have been conducted on a huge diversity of physiological and ecological traits (3, 6, 12, 14–17). Comparative studies of these intraspecific data have tended to focus on a subset of available data (16, 18–21). A broad-scale comparative analysis of intraspecific thermal responses has not been performed previously because of a lack of a comprehensive database. As we now show, this approach provides new insights into the general features of thermal responses not accessible with interspecific studies.

We construct from the literature a database containing 2,445 intraspecific temperature responses. Our ecoinformatics approach allows us to: (i) combine these data into a single database with consistent measurement units and trait definitions and (ii) describe patterns that suggest mechanisms responsible for generalities and deviations in the thermal dependence of biological traits. We compile data on both physiological and ecological traits but focus on those central to species interactions (*SI Appendix*, Table S1). The thermal response of interaction traits can be strongly influenced by organismal behavior (22–25), so we focus on how biological processes are executed (e.g., attack body velocity, handling rate) and not on decisions (e.g., attack probability, defense behavior probability) about whether to execute them. Requiring each response to have nonzero measurements at a minimum of four distinct temperatures that cover a range of at least 5 °C yields 1,072 responses. Our ontology categorizes these responses into 112 distinct traits that span levels of biological organization from internal physiology to species interactions (Fig. 1 and *Materials and Methods*). Traits were measured in marine, freshwater, and terrestrial habitats for 309 species of plants, microbes, and animals.

Thermal responses are typically unimodal over the full temperature range, but many studies only record measurements for a restricted temperature range over which responses typically rise or fall monotonically (3, 4, 8). Consequently, we analyze three components of the thermal response: the initial increase in the trait value with temperature (rise), its ultimate decrease at higher temperatures (fall), and the transition between the rise and fall components (unimodal) (*SI Appendix*, Fig. S1). After combining pseudoreplicates (*SI Appendix, SI Materials and Methods*), this process yields 374 rise, 70 fall, and 240 unimodal responses (minimum temperature range was increased to 10 °C for unimodals to capture both the rise and fall components).

Results

Our analyses of these data reveal four novel aspects of the thermal responses of biological traits.

Mean Activation Energy of Trait Rises. We find a general pattern in the rise component, which covers the temperature range over which organisms commonly operate under natural conditions (3, 26). The metabolic theory of ecology (MTE) suggests that the Boltzmann–Arrhenius model from chemical reaction kinetics can be used to predict the rise of many biological rates and times, including systematic effects on metabolic rate (2–5, 8, 27–29). According to the MTE, the scaling of a biological rate, R, with body temperature, T, is

$$R = R_o e^{-E/kT} \quad [1]$$

where E is activation energy, k is Boltzmann's constant, and R_o is an organism- and state-dependent scaling coefficient. Interspecific studies have found that the activation energy, E, of most

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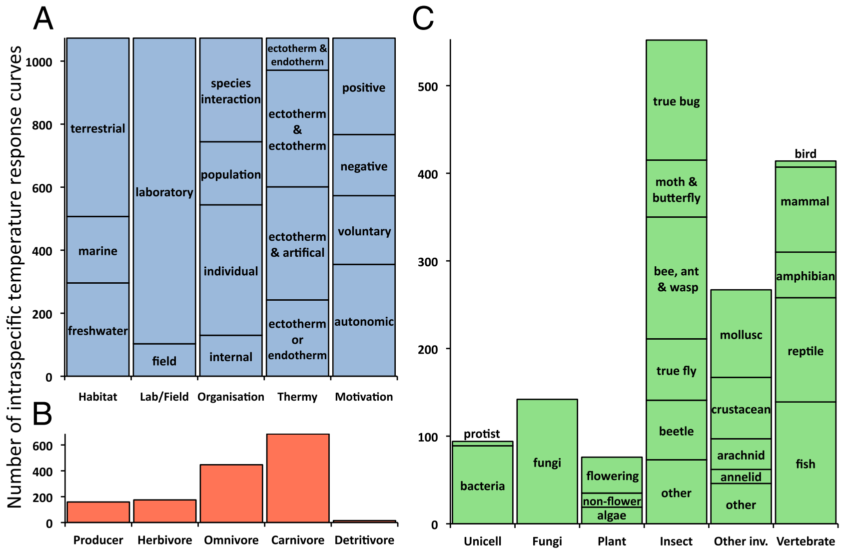

Fig. 1. Diversity of intraspecific temperature responses analyzed in our study. Total number of thermal response data for habitat, laboratory/field, level of biological organization, and thermy of predator or prey (traits involving single species) or predator and prey (traits involving interactions between two species) (artificial taxa are shown in *SI Appendix*, Table S3) as well as motivation (main text) (*A*), trophic group (*B*), and taxonomic group (*C*). *B* and *C* sum to more than 1,072 (the total number of responses) because species interactions include multiple species. Further details on trait categories and data sources are provided in *SI Appendix*.

rises centers at or near 0.65 eV (2, 4, 18). However, activation energies for important metabolic reactions vary from ~0.2–1.2 eV (4, 18, 27), with 0.65 eV being near the middle of this range. Some variation around this value is therefore expected. This range corresponds to Q_{10} values (change in trait value when temperature is changed by 10 °C) of about 1.31–5.13 when averaged over 0–40 °C (*SI Appendix*, Table S2). Of the 374 intraspecific rises we analyze, 87% are consistent ($R^2 \geq 0.5$, $P < 0.05$) with the Boltzmann–Arrhenius model. The mean activation energy, E, of these responses is 0.66 ± 0.05 eV [mean ± 95% confidence intervals (CIs) used throughout our paper] (Fig. 2*A*). The 95% CIs include the value of 0.65 eV reported across species for the MTE. The generality of this result across traits, taxa, trophic groups, levels of organization, and habitats (Fig. 1) may be attributable to the influence of metabolic rate on a wide range of biological processes (2, 30). Indeed, for rises that are significant, the vast majority (88%) of activation energies are between 0.2 and 1.2 eV, corresponding to the range observed for metabolic reactions (4). Even at the population level, where variance is largest, 80% of all activation energies fall between this range (Fig. 2*A*). Of trait rises whose relationship to metabolic rate is more obvious (i.e., rates, times), a higher proportion (281 of 319) are significantly fit by the Boltzmann–Arrhenius model than those less clearly linked to metabolism (41 of 55), such as conversion efficiencies, optimal muscle strain, and angle of body turning during escape. Of all rises well fit by the Boltzmann–Arrhenius model, about a quarter have residuals with curvature, the vast majority of which are concave (downward). Such deviations from the Boltzmann–Arrhenius model have been observed previously in growth rate data (31, 32) (*Discussion*).

Distribution of Activation Energy for Trait Rises. We find systematic deviations around the mean activation energy of 0.66 eV for rise responses. The most noticeable deviation is strong right skewness (Figs. 2 *A* and *B* and 3), which is consistent across levels of organization, taxa, habitats, and trophic groups. For unconstrained random processes, this right skewness indicates deviations from

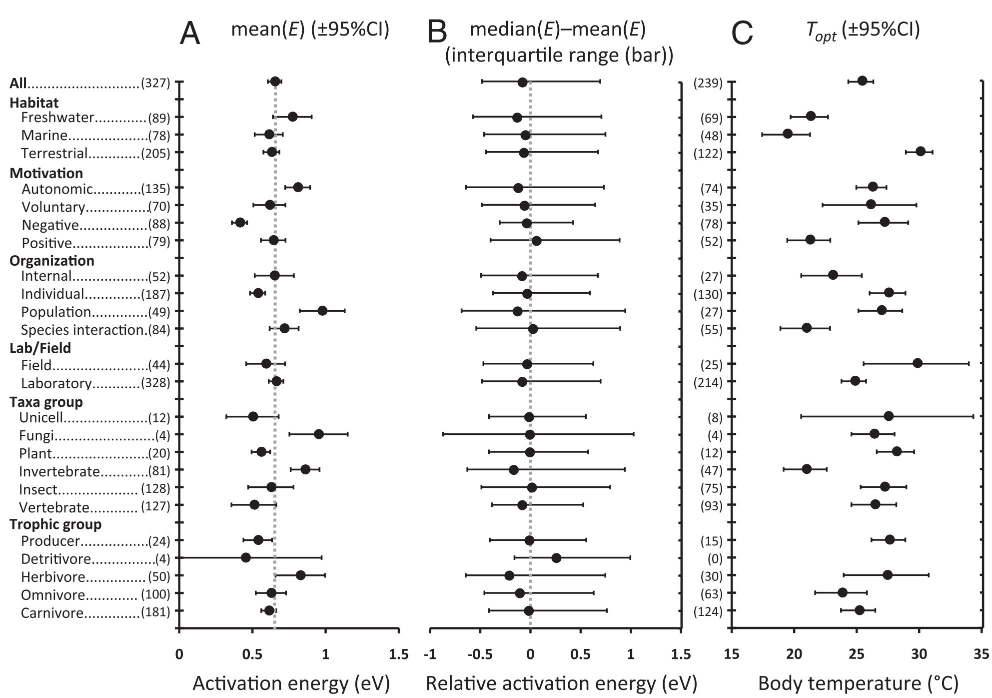

Fig. 2. Analysis of activation energies, E, for rise responses and temperatures for optimum trait values, T_{opt}. (*A*) Mean E (±95% CI) of intraspecific rise responses calculated from the Boltzmann–Arrhenius model. Responses are grouped by habitat, motivation, level of biological organization, laboratory or field measurements, taxa, and trophic group. The vertical dotted line marks 0.65 eV, as reported for interspecific studies within the MTE. (*B*) Relative activation energy [median (E) – mean (E)] of intraspecific rise responses bounded by the interquartile range. Symmetrical distributions have an equal mean and median, and thus a relative activation energy of zero (vertical dotted line). Most medians lie below zero, indicating right skew. (*C*) Mean T_{opt} (±95% CI) of intraspecific unimodal responses. All values in parentheses are sample sizes with pseudoreplicates combined. Trait categorizations, definitions, treatment of pseudoreplicates, and data sources are provided in *SI Appendix*.

normality and random error (*SI Appendix, SI Materials and Methods*). In principle, right skewness for the rises can be produced by a random diffusion process constrained by a reflective boundary (33) at 0 eV. However, this mechanism does not explain our results because (*i*) there should be more activation energies close to the boundary (0 eV) than are observed (Fig. 3), indicating the boundary effect is either nonexistent or negligible, and (*ii*) different degrees of skewness, including lack of skewness, are observed in certain traits (Fig. 2*B*) (18). The right skewness we observe therefore represents a real and unexplained biological signal.

Independent of mechanism, this right skewness means that the majority of trait responses have activation energies below 0.66 eV (median of 0.55 eV) (Figs. 2*B* and 3). The MTE does not predict and cannot currently explain why the distribution of activation energies is right-skewed, and thus why the majority of rise responses have activation energies lower than 0.65 eV. Therefore, the MTE needs to be assessed to determine whether or not it can be extended to explain the full form of the distribution of activation energies and its biological consequences.

One possible mechanism driving skewness in rise activation energies is trait motivation. We define autonomic traits as those that largely act below the level of consciousness, such as basal metabolic rate, whereas somatic traits are largely under conscious control (34). We further classify somatic traits as negative (defense or movement away from a stimulus), positive (consumption or movement toward a stimulus), or voluntary. Body velocity, for example, can be negative (e.g., escape body velocity), positive

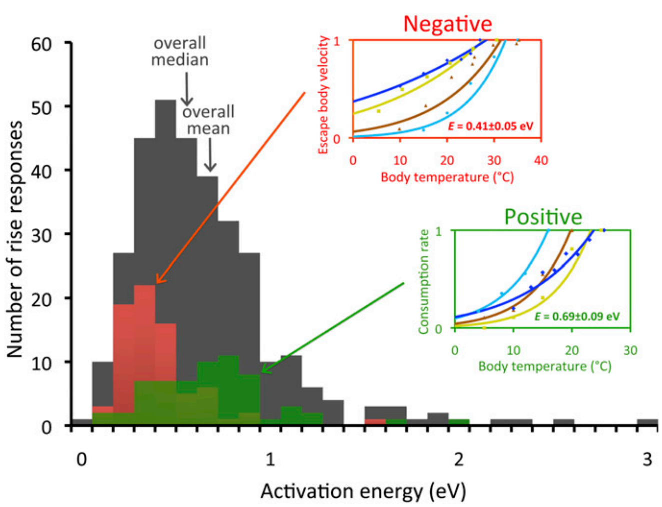

Fig. 3. Histograms of intraspecific activation energies. Gray columns are the total number of rise responses, red columns are the subset of these responses that correspond to negative motivation, and green columns are the subset of these responses that correspond to positive motivation. (*Insets*) Examples of responses of traits corresponding to positive (green) and negative (red) motivations, respectively. OLS regressions based on the Boltzmann–Arrhenius model (Eq. **1**) were fitted to the rise component of each response. Trait values are normalized relative to the maximum trait value in each data series to present multiple responses on the same scale. Values of E for insets are mean values for all negative and positive motivation traits. Escape body velocities (m/s) (negative motivation) of the northern desert iguana (light blue circle, $E = 0.96 \pm 0.52$ eV), western fence lizard (brown triangle, $E = 0.63 \pm 0.28$ eV), African clawed frog (dark blue diamond, $E = 0.25 \pm 0.06$ eV), and wandering garter snake (yellow square, $E = 0.36 \pm 0.14$ eV) are shown. Consumption rates [consumed prey/(predator * s)] (positive motivation) of river perch preying on phantom midge larvae (light blue circle, $E = 0.99 \pm 0.25$ eV), back-swimmer preying on culex mosquito larvae (brown triangle, $E = 1.09 \pm 0.46$ eV), dampwood termite feeding on eucalyptus tree (dark blue diamond, $E = 0.65 \pm 0.40$ eV), and atlantic oyster drill preying on eastern oysters (yellow square, $E = 1.18 \pm 0.83$ eV) are shown. Trait definitions, data fitting methods, and data sources are provided in *SI Appendix*.

(e.g., attack body velocity), or voluntary (e.g., voluntary body velocity). Analysis of trait rises reveals that negative motivation traits have significantly lower mean activation energies (0.40 ± 0.05 eV) than do positive (0.69 ± 0.09 eV), voluntary (0.64 ± 0.12 eV), or autonomic (0.76 ± 0.08 eV) traits (Figs. 2*A* and 3). Because negative motivation traits make up 23.4% of all rises and typically have lower activation energies, they contribute substantially to the right skewness observed across taxa and habitats (Fig. 3).

This difference in activation energies means that traits with negative motivation are less sensitive to temperature than traits that are positive or voluntary, and thus supports the hypothesis that stronger selection pressure on prey to escape capture and death [the life-dinner principle (35–37)] results in maintenance of nearly optimal performance across a range of temperatures. That is, although it is energetically costly to maximize effort at low temperature (3), individuals under attack may do so for survival. Prey presumably increase their performance at lower temperatures rather than decrease their performance at higher temperatures, which would more likely result in being captured by a predator. This differential performance is consistent with physiological limitations (38) or shifts in motivation at low vs. high temperatures (22–25). Moreover, diurnal and seasonal variation in temperature could allow the evolution of differences in, for example, the thermal response of attack and escape velocities needed for an individual to alternate between being both a predator and a prey.

By focusing only on body velocities, we can directly test the life-dinner principle. Consistent with the principle, rises for escape body velocity (0.39 ± 0.05 eV) have lower activation energies than do voluntary velocities (0.52 ± 0.09 eV). Moreover, we can quantify how much faster the mass-corrected coefficient (R_o in Eq. **1**) at 20 °C for escape body velocity (2.61 m/s) is than for voluntary body velocity (0.31 m/s) (*SI Appendix, SI Materials and Methods*). These values represent averages across diverse taxa and are qualitatively similar to previous results for lizards that do not examine thermal effects (39, 40). For this analysis, we only included responses for which the individual was clearly and continually moving at a nearly constant velocity, thus precluding other effects and explanations related to behavior and shifts in motivation or strategy (*Materials and Methods*). Because escape or attack velocity is largely anaerobic and is governed by different biochemical pathways than voluntary velocity (41, 42), it may experience different selection pressures, contributing to differences in activation energies for thermal responses.

ANOVA of all rises shows that level of organization is also a strong predictor of mean rise activation energies (*SI Appendix*, Table S4), with internal (0.65 ± 0.13 eV) and individual (0.54 ± 0.05 eV) having a much lower mean E than population (0.98 ± 0.15 eV) (Fig. 2*A*). Fig. 4 shows rise activation energies for three major taxonomic lineages—terrestrial insects, fish, and lizards—categorized by level of organization. For all taxa, mean rise activation energies averaged across all traits are, again, very close to 0.65 eV (Fig. 4). Although data are too sparse to draw general conclusions, activation energies of trait rises are more variable and tend to increase from internal and individual traits to population and species interaction traits for insects and lizards (Fig. 4 and *SI Appendix*, Table S4).

Trait Falls. Few data or theories exist for the decline of trait performance at higher temperatures, and the data that do exist are often not of high quality. Protein degradation is considered a likely mechanism for falls of some traits (7, 38, 43), and in those cases, activation energy can be interpreted as the energy of degradation processes. Of the 70 fall responses we analyze, the mean E of the 31 significant falls is 1.15 ± 0.39 eV and the median is 0.65 eV, indicating strong right skewness as found for trait rises. Falls have much higher activation energies than rises, consistent with the left skew typically observed in temperature responses (3, 5, 7, 26). We also find that several trait falls are conversion efficiencies (*SI Appendix*, Table S3), contradicting the common tacit assumption of their temperature invariance (2, 9, 30, 44).

Optimal Temperature and Unimodal Responses. For the 240 unimodal responses, the mean temperature at which optimal trait values occur (T_{opt}) is 25.3 ± 1 °C. Although temperature fluctuates more in terrestrial habitats than in freshwater or marine habitats, we find no evidence that T_{opt} is more variable for terrestrial taxa (Fig. 5). Our results cannot be attributed to factors such as the more homogeneous thermal landscape of aquatic habitats (45–49), because most of our data were measured in experimental arenas with constant temperatures (*Materials and Methods*). Therefore, organisms were not able to thermoregulate behaviorally, effectively eliminating differences between body and ambient temperature. Habitat is by far the strongest determinant of mean T_{opt} (Figs. 2*C* and 5 and *SI Appendix*, Table S5). Traits for terrestrial organisms have a higher mean T_{opt} (30 °C) than those in freshwater (21 °C) or marine organisms (19 °C). These differences correspond to environmental temperatures (50), indicating a matching between environmental temperatures and those for near-optimal performance (3, 51).

Discussion

Our ecoinformatics analysis illuminates previously unrecognized generalities and deviations in how biological systems respond to temperature. We show that almost 90% of our intraspecific rise responses are well fit by the Boltzmann–Arrhenius model. Across all traits, the mean activation energy is 0.66 eV, close to the value of 0.65 eV reported for interspecific responses and indicating that metabolic rate potentially affects a wide range of biological processes (2, 4, 8, 28, 30). Nonetheless, we find systematic and substantial patterns in the variation of activation energies around this canonical value, including persistent right skewness in the distribution. Notably, the median value of activation energies is 0.55 eV, indicating that most activation energies are lower than 0.65 eV. Our results highlight limitations in the precision, power, and utility of the MTE as it currently stands. We conclude that the MTE requires reassessment and modification to discover whether it can explain these novel features of thermal responses.

The persistent right skewness in the distribution of activation energies raises important questions about whether to interpret the mean or median as the most biologically relevant measure. We expect that processes involving individuals or single species may be more affected by the median, because most individuals and species will have activation energies close to this value. In contrast, ecosystem processes may be determined more by the mean value because they represent an average over many individuals, species, and processes.

Folding the Boltzmann–Arrhenius model into a more realistic unimodal model (7, 13, 52) should prove insightful in this regard and may help to explain recently observed deviations of growth rate data fit to the model, including effects of the values and range of chosen experimental temperatures (32). Further elucidation of these effects requires more high-quality experimental data. Detailing the response of traits over the entire temperature range has been central to understanding and making predictions about the effects of climate change (53). We therefore encourage experimentalists to measure the response of a greater diversity of traits over the full temperature range, thus allowing characterization of the entire unimodal response.

The right skewness we observe in the distribution of activation energies persists across nearly all trait categories. Detailed analyses of these and similar patterns suggest dominant selection pressures and novel biological mechanisms. Differences between negative and positive motivation can be explained by a thermal version of the life-dinner principle (35–37), which predicts systematic differences in the thermal responses of organisms when they are acting as either a predator or a prey. Collecting more high-quality data for the thermal dependence of attack velocity is a high priority for more sensitive tests of the life-dinner principle.

We find that activation energies for rises are generally more variable and tend to increase as one moves from internal and individual traits to population and species interaction traits. This increase represents enhanced thermal sensitivity of populations and species interactions, potentially reflecting density or frequency dependence. These patterns probably have important consequences for species interactions and community stability, and their identification suggests that scaling constraints can be shifted or relaxed by evolutionary or behavioral processes. Data on multiple traits within single species will also help to resolve our understanding of how temperature influences the interaction and integration of traits across different levels of biological organization (54). Investigation

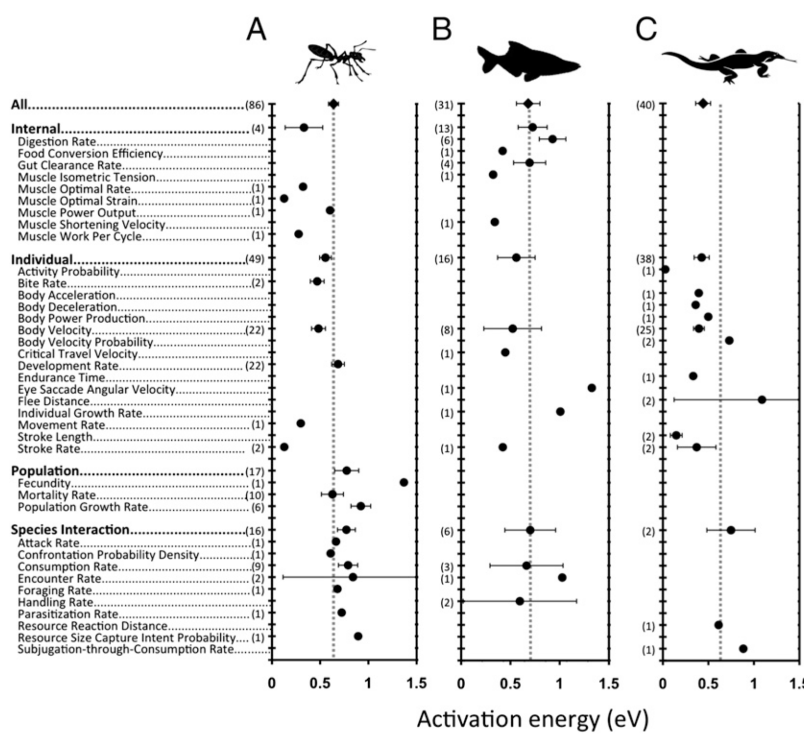

Fig. 4. Mean activation energies, E (±95% CI), of intraspecific rise responses calculated using the Boltzmann–Arrhenius model are categorized by different levels of organization for terrestrial insects (*A*), marine and freshwater fish (*B*), and terrestrial lizards (*C*). The vertical dotted lines mark 0.65 eV reported for interspecific studies (2, 4, 18). All values in parentheses are sample sizes with pseudoreplicates combined. Trait definitions, treatment of pseudoreplicates, and data sources are provided in *SI Appendix*.

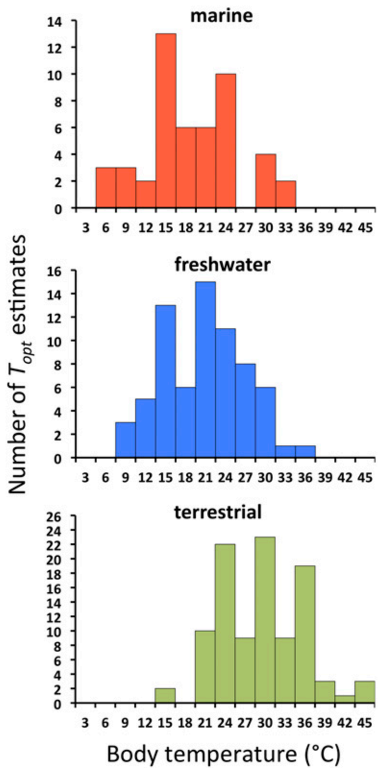

Fig. 5. Histograms of T_{opt} categorized by habitat. The optima at 15 °C, 20 °C, 25 °C, 30 °C, and 35 °C likely represent overrepresentation of these temperatures in experimental studies. Data sources are provided in *SI Appendix*, Tables S3 and S6.

of the distribution of activation energies at the lowest level of organization, biochemical reactions, may reveal baseline variation that could be amplified across biological levels. For example, the distribution of activation energies based on a small sample of 11 biochemical reactions (table 3.1 in ref. 27) is right-skewed and may also contribute to the pervasive right skewness observed in our data.

Our trait ontology is a first categorization of thermal response curves and allows us to identify novel patterns and propose new mechanisms, such as right skewness and the life-dinner principle. Alternative categorization of the traits in our database will likely reveal other biological mechanisms. Because life evolves and operates across a complex thermal landscape, it is essential to synthesize empirical knowledge and to deduce general mechanisms for shifts in the thermal responses of biological traits. Our work is an important step along this path and should aid research on how species, communities, and ecosystems respond to changes in temperature.

Materials and Methods

Data Acquisition. We searched the literature for studies that measured the intraspecific temperature response of biological traits, with a focus on those central to species interactions (main text). We found 273 data sources, including journal articles, published reports, and books. When possible, we contacted authors directly to obtain raw data. Otherwise, we extracted data directly from tables and text or from figures using DataThief (55). This process yielded 2,445 intraspecific temperature responses and 20,394 data points. We primarily selected studies where environmental conditions, such as precipitation, light, and prey density, were either controlled or standardized. Consequently, most responses (92.5%) were measured in the laboratory, where body temperature of ectotherms was known to be close to ambient (based on direct measurement and extended times at test temperatures). The 192 sources from which data were described and analyzed in this paper are listed in *SI Appendix*, Table S6 and in the raw data in *SI Appendix*, Table S3.

Trait Ontology. We constructed an ontology that allowed us to classify biological traits in a way that permits subsets of data to be easily isolated and analyzed, and that defined categories of data closely tied to ecological measurements, intuition, and mechanisms. Construction of a universally accepted trait ontology is currently not achievable, and although our ontology (*SI Appendix*, Table S1) captures important patterns in the data, categorization of traits in other ways will likely reveal additional biological mechanisms. In this paper, we describe two main components of our ontology: level of biological organization and trait motivation. Levels of biological organization we define are internal (processes internal to the organism), individual (processes at the level of individual organisms that include mechanical interactions with the external environment), population (processes for a group of conspecific individuals), and species interaction (processes involving interaction between two or more species). Trait response can be strongly influenced by the motivation of an organism. For example, how fast an organism moves through the landscape depends not only on its morphological capacity and how this capacity interacts with the environment but on its motivation (36, 39, 40). We therefore also categorize trait motivation, which we define in the main text. *SI Appendix*, Tables S1 and S3 detail the classification of each data series into this ontology.

Unit Conversions. Definitions and measures of many traits are inconsistent throughout the literature, so we identified equivalent traits and converted them to comparable definitions and units. All times were converted to rates to ensure a single currency. For consistency, and because of the counterintuitive nature of many mass-specific traits (e.g., detection distance), mass-specific units were converted to per number of individuals (i.e., per capita). Activation energies were the same whether traits were expressed per mass or per capita. Scaling coefficients were mass-corrected. Further discussion of intercept coefficients and their analysis, and a description of how species wet mass was estimated, are provided in *SI Appendix, SI Materials and Methods*.

Data Quality and Classification. To be included in our analysis, trait responses must have had (*i*) nonzero measurements at four or more distinct temperatures (thermal response models require a minimum of two free parameters) and (*ii*) a temperature range spanning at least 5 °C (it is difficult to differentiate statistically between linear and Boltzmann–Arrhenius model fits over smaller temperature ranges). For responses that satisfied these two criteria, we used ordinary least squares (OLS) regression to fit quadratic functions and then classified responses based on statistically significant coefficients as being rising, falling, or unimodal. For responses not fit well by a quadratic function, we calculated the correlation coefficient to categorize it as either rise or fall, or if our criterion for biological significance ($R^2 \geq 0.5$, P value < 0.05) was not met, it was excluded (8.3% of responses). Because unimodal responses include both rise and fall components, the minimum temperature range for inclusion was doubled to 10 °C for unimodals. Responses classified as being unimodal were further subdivided into rise (fall) components by iteratively removing trait measurements at upper (lower) terminal temperatures until monotonicity was observed in a contiguous subset of the response (*SI Appendix*, Fig. S1). After each data point removal, we reassessed whether a quadratic or cubic model fit better than a linear model. The model selection was done using the small-sample Akaike Information Criterion (AIC) value (56). In cases where only four points remained after removal of terminal points, an F test was used instead. The original unimodal responses were retained after their monotonic portions were extracted. Thus, we obtained three separate categories of temperature responses: rise (802), fall (239), and unimodal (536). These numbers include pseudoreplicates (*SI Appendix, SI Materials and Methods*), and rise and fall categories include responses that were extracted from the unimodal set. The MATLAB (MathWorks) code used for this procedure is available on request.

Data Analysis of Monotonic Rise and Fall Temperature Responses. We assessed fits and calculated E of both trait rises and falls for the Boltzmann–Arrhenius model in the same way. The fit of each response to the Boltzmann–Arrhenius model (Eq. **1**) was assessed by OLS regression of log-transformed trait values on the reciprocal of temperature (in Kelvin). OLS regression was appropriate because temperatures are typically measured with much less error than trait values. The Boltzmann–Arrhenius model predicts that the transformed data would be best fit by a straight line. We considered the Boltzmann–Arrhenius model to fit a response if $R^2 \geq 0.5$ and the F test P value is <0.05. These relatively liberal criteria allowed us to use a larger set of responses to analyze deviations from the Boltzmann–Arrhenius model. We assessed how many responses showed concave upward or downward deviations by analyzing the residuals of the fits from above. Using OLS regression, we fit the residuals with a quadratic model using the same R^2 and P values as above to determine significance. The direction and magnitude of the curvature of residuals were recorded (values of the coefficient of the quadratic term). We could not use the small-sample AIC here to differentiate between a quadratic and linear fit to the residuals because most of our data consist of four points, for which the small-sample AIC cannot be calculated. To estimate the activation energies of trait rises, we calculated both ordinary and weighted averages of measured activation energies, *E*. Weights were calculated as the ratio of the total number of data points in each response to the total number of data points in all responses within a category (e.g., trait, taxon, habitat, level of organization, motivation). Weighted and unweighted 95% CIs were calculated for the respective means. We also calculated medians, skewness, and quartiles of the *E* in each category. We used ANOVA to detect differences in mean *E* between categories of rise responses, such as level of organization or habitat (*SI Appendix*, Table S4), but not for falls because of an inadequate sample size. We also tested whether the distribution of intercept coefficients (Eq. **1**) was normal (*SI Appendix, SI Materials and Methods*).

Data Analysis of T_{opt}. For unimodal responses, we estimated T_{opt} as the temperature at which the maximum trait value was recorded. For responses with multiple maximal values (within 5% of each other), we calculated their average temperature (*SI Appendix, SI Materials and Methods*). As described above for activation energies of rise and fall responses, values of T_{opt} across trait categories were compared using ANOVA (*SI Appendix*, Table S5).

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Supporting Information

Systematic Variation in the Temperature Dependence of Physiological and Ecological Traits

Anthony I. Dell, Samraat Pawar, & Van M. Savage

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SI Materials and Methods

Body Size Estimation. Wet mass estimates for each species are required to calculate mass-corrected scaling coefficients and to interconvert between mass-specific and per capita trait measurements. The diversity of taxa in our data and the large number of mass estimates necessitated automation of this process, so for cases when wet body mass is not given in the original source, we create and use an algorithm that assigns a wet mass estimate to species in each data series. This algorithm is based largely on the taxonomic relatedness to published size estimates and length-mass regressions, and allows us to rapidly obtain estimates of wet body mass that well match published measurements. Our algorithm comprises four main steps: 1) body size measurements (mass, length, or otherwise) are acquired from the original data source when available; 2) When no size estimate is given in the original source (38% of responses), body size is assigned using measurements compiled from the literature into a database; 3) All non-mass estimates of size are converted to mass (wet, dry, or ash-free-dry) using 364 published size-mass regressions. To be conservative, we do not extrapolate outside the non-mass size range of individuals that were used to construct these regressions; 4) All non-wet masses are converted to wet mass using 10 published taxon-specific conversion ratios. This algorithm relies on a richer set of literature data and regressions than previous studies.

Analysis of Intercept Coefficients for Monotonic Rise and Fall Responses. Random error in fitted regression parameters will typically result in a normal distribution. Our measured intercept coefficients (Eq. 1) are indeed distributed approximately normally. Thus the right-skewness observed in activation energies (Fig. 2 & 3) is most likely biologically significant. For analysis of effect of motivation on body velocity (in our test of the life-dinner principle, see main text) we calculate intercept coefficients at 20°C across all traits (standardized intercept). The exponentials of the resulting intercepts are the predicted trait values at 20°C. We correct these standardized values for the effect of body mass by multiplying each value by $m^{-1/4}$, where m is the mass of the consumer species (resource mass was used for traits that had negative motivation). Choosing any other standardization temperature between 0 and 50°C, or an allometric scaling exponent of 1/3, does not qualitatively affect our results.

Estimation of T_{opt}. We compare the T_{opt} values estimated as the temperature at which the maximum trait value occurs (main text), with those obtained by fitting a unimodal function (Fig. S1). We choose the Johnson & Lewin (1) model, a unimodal extension of the Boltzmann-Arrhenius function (Eq. 1) for trait rises (2-7):

$$h(T) = ce^{-\frac{E}{kT}} \Big/ 1 + e^{-\frac{1}{kT}\left(E_D - \left(\frac{E_D}{T_{opt}} + k\ln\left(\frac{E}{E_D - E}\right)\right)T\right)} \tag{2}$$

Here the additional thermodynamic parameter E_D determines the steepness of decline of the trait values at temperatures higher than T_{opt}, while c is a constant. All responses classified as being unimodal are fitted to this model using nonlinear least-squares regression (8). We use the Levenberg-Marquardt algorithm with a maximum of 2000 iterations and error tolerance of 1×10^{-30}. Reasonable response-specific initial values are allocated for the parameters to improve algorithm convergence and parameter estimation. We find that the overall mean T_{opt} value obtained from the unimodal model fits (26.0°C) is comparable with that from the direct method described above (25.3°C). We use the direct method for T_{opt} estimation because 38% of the fits to the Johnson & Lewin model have very large confidence intervals (bounds > 25% away from the mean).

Treatment of Pseudoreplicates. We define pseudoreplicates as responses that share taxa (or combinations of taxa for species interaction traits) and experimental conditions. From each pseudoreplicate group, we obtain a single value of the parameters E, T_{opt} and scaling coefficient by taking the weighted average of their estimates across the individual responses in that group. The weights are a linear function of the mean number of data points across responses within each pseudoreplicate group.

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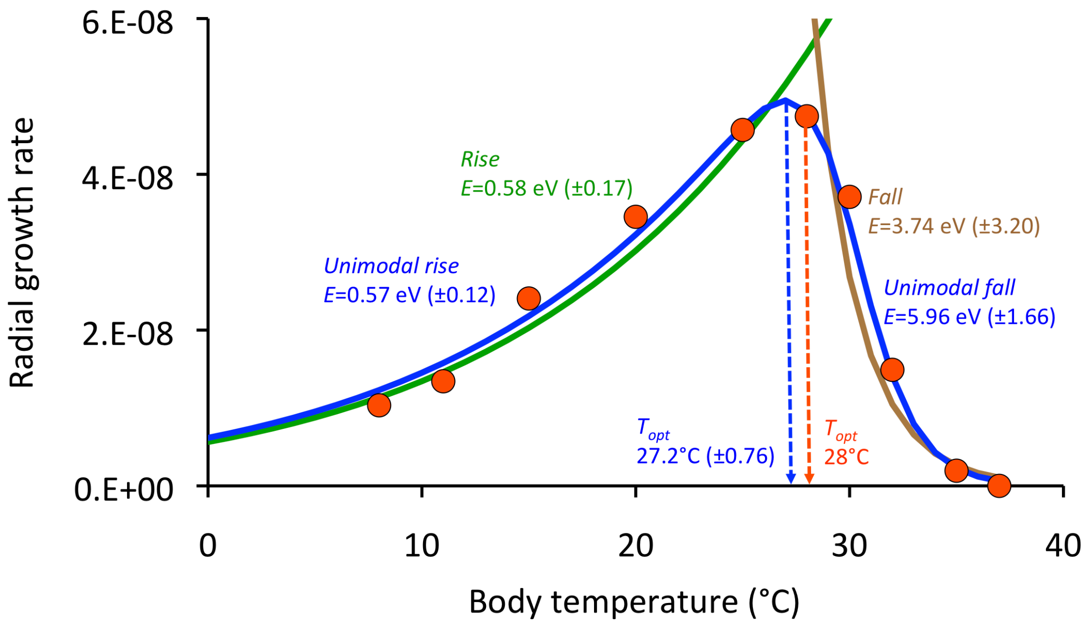

Fig. S1. The unimodal thermal response of radial growth rate of sac fungi (m / (colony * s)). Green and brown curves are OLS regressions to the Boltzmann-Arrhenius model (Eq. 1) for the subset of data that are the rise and fall components, respectively. These components were extracted by the algorithm described in the Materials and Methods. For this particular response, the rise was obtained by the algorithm through removal of the measurements at the 4 highest temperatures and the fall through removal of measurements at the 5 lowest temperatures. The blue curve is the best fit to the Johnson & Lewin model (SI Methods) (1). Values shown are estimated activation energies with 95% confidence intervals for the respective response components. Dotted vertical arrows are estimated temperatures for T_{opt}–the temperature at which the trait value is optimal–calculated from the direct method (red) and Johnson & Lewin model (blue). See SI for more details. Data are from Fargues et al. (9).

Table S1. Trait definitions. Traits are listed alphabetically within level of organization. Unless stated otherwise, traits are measured per capita (i.e., per individual). All measurements are listed in SI units. C_n (R_n) is the number of individual consumers (resources). When the trait involves a single species, C_n is used as the default. Times are denoted as 'organism * s' so that rates are interpreted as per individual, because rate is our focal unit. A (arena size) is measured as area or volume depending on the dimensionality of the habitat, as determined by the original authors. We standardize by resource and consumer density whenever possible, and this is the default unit of all traits listed below. Weights are wet mass unless otherwise stated. Original trait definitions and units are given in the original sources (Table S3 & S6).

Trait name	**Trait unit**	**Motivation**	**Trait definition**
Internal			
Ammonia Excretion Rate	kg / (C_n * s)	autonomic	Rate of ammonia (NH_3) mass excretion per consumer.
Digestion Rate	R_n / (C_n * s)	autonomic	Rate at which resources are digested per consumer.
Faecal Excretion Rate	kg / (C_n * s)	autonomic	Rate of faecal mass excretion per consumer.
Feeding Heart Beat Rate	event / (C_n * s)	positive	Rate of heartbeats per consumer while filter feeding.
Filtration Metabolic Efficiency	m^3 / (m^3 * C_n)	autonomic	Metabolic efficiency of the filtration process expressed as water volume per oxygen volume per consumer.
Food Energy Assimilation Efficiency	proportion / C_n	autonomic	Efficiency of digesting ingested energy per consumer expressed as the amount of energy that is digested in proportion to that which is ingested.
Food Mass Conversion Efficiency	proportion / C_n	autonomic	Efficiency of converting food mass to body mass per consumer expressed as growth in tissue mass in proportion to total mass of resource consumed.
Gut Clearance Rate	event / (C_n * s)	autonomic	Rate food moves through a consumer from initial ingestion to evacuation (i.e., faeces).
Gut Loading Rate	event / (C_n * s)	autonomic	Rate at which the gut physically fills with food.
In Vitro Heart Beat Rate	event / s	autonomic	Rate of heartbeats measured in a heart removed from a living organism.

Trait name	Trait unit	Motivation	Trait definition
In Vitro Muscle Isometric Tension	N / m^2	autonomic	Isometric tension of muscle measured in muscle removed from a living organism.
In Vitro Muscle Optimal Phase	proportion	autonomic	Phase at which the power output of the muscle is maximum in muscle removed from a living organism.
In Vitro Muscle Optimal Rate	event / s	autonomic	Optimal frequency corresponding to the maximum power output of the muscle removed from a living organism.
In Vitro Muscle Optimal Strain	proportion	autonomic	Strain at which the power output of the muscle is maximum in muscle removed from a living organism.
In Vitro Muscle Power Output	W	autonomic	Power output of muscle measured in muscle removed from a living organism.
In Vitro Muscle Shortening Velocity	m / s	autonomic	Velocity of muscle shortening measured in muscle removed from a living organism.
In Vitro Muscle Work Per Cycle	J / event	autonomic	Muscle work per cycle at optimal frequency measured in muscle removed from a living organism.
Log-Linear Gut Clearance Rate	event / (C_n * s)	autonomic	The slope of the regression of log gut content mass per consumer individual per time.
Oxygen Mass Scope For Activity	kg / (C_n * s)	voluntary	Amount of oxygen available for use for activity measured as rate of oxygen mass production per consumer.
Photosynthetic Oxygen Production Rate	kg / (C_n * s)	autonomic	Organic oxygen mass production rate per consumer through photosynthesis.
POC Photosynthetic Oxygen Production Rate	kg / (kg * s)	autonomic	Carbon-specific (POC) oxygen mass production rate through photosynthesis.
Respiration Rate	kg / (C_n * s)	autonomic	Organic oxygen mass consumption rate per consumer during respiration.
Square Root-Linear Gut Clearance Rate	event / (C_n * s)	autonomic	The slope of the regression of square root gut content mass versus time.

Trait name	Trait unit	Motivation	Trait definition
Surface Area-Specific Dark Respiration Rate	kg / (m^2 * s)	autonomic	Surface area-specific CO2 production during dark respiration.
Surface Area-Specific Maximum Photosynthesis Rate	kg / (m^2 * s)	positive	Surface area-specific maximum photosynthesis rate.
Surface Area-Specific Mitochondrial Respiration Rate	kg / (m^2 * s)	autonomic	Surface-area specific respiration rate in leaf mitochondria during photosynthesis.
Surface Area-Specific Photosynthetic Oxygen Production Rate	kg / (m^2 * s)	autonomic	Surface area-specific oxygen production rate during photosynthesis.
Voluntary Heart Beat Rate	event / (C_n * s)	voluntary	Rate of heartbeats measured in an organism that is voluntarily stationary.
Individual			
48-hr Hatching Probability	proportion / C_n	autonomic	Probability of an egg having hatched at 48 hrs.
Avoidance Body Velocity	m / (R_n * s)	voluntary	Velocity of the body during movement in avoidance of a weak stimulus (differs from Escape Body Velocity because the stimulus is not an immediate threat).
Bite Rate	event / (C_n * s)	positive	Rate of bites or analogue (e.g., radular scrape) per consumer.
Critical Holding Velocity	m / (R_n * s)	negative	Velocity at which animal failed to hold position on the substrate when placed in a multi-speed flow chamber for a set time at sequentially increasing speeds.
Critical Travel Velocity	m / (R_n * s)	negative	Velocity at which an individual fails to maintain when placed in a multi-speed flow chamber for a set time at sequentially increasing speeds.
Critical Upright Time	R_n * s	negative	Time taken for animal to become completely exhausted from repeated up-righting of body.

Trait name	Trait unit	Motivation	Trait definition
Development Rate	$1 / (C_n * s)$	autonomic	Rate at which individuals complete development of one or more life stages.
Endurance Time	$R_n * s$	negative	Time maintained on a single-speed treadmill or flow chamber until exhaustion during escape locomotion.
Escape Angle of Body Turning	rad / R_n	negative	The sum of the absolute angles of turning of the head relative to the body during escape burst locomotion.
Escape Angular Rate of Body Turning	rad / (R_n * s)	negative	Velocity of the turning of the front of the resource relative to the mid-point throughout movement during escape burst locomotion.
Escape Body Acceleration	m / (R_n * s^2)	negative	Acceleration of the whole body during escape burst locomotion.
Escape Body Deceleration	m / (R_n * s^2)	negative	Deceleration of the whole body during escape burst locomotion.
Escape Body Power Production	W / R_n	negative	Power production of the whole body during escape burst locomotion.
Escape Body Response Rate	event / (R_n * s)	negative	Rate of response of a resource to an attacking consumer or otherwise negative stimulus.
Escape Body Velocity	m / (R_n * s)	negative	Velocity of the whole body during escape burst locomotion.
Escape Body Velocity Probability	proportion / R_n	negative	Velocity of the whole body during escape burst locomotion expressed as the ratio of sprint velocity of an individual to the maximum velocity of that individual in all trials at all temperatures.
Escape Gait Change Velocity	m / (R_n * s)	negative	Velocity at which resource changes gait during escape burst locomotion.
Escape Jump Contact Rate	event / (R_n * s)	negative	Rate of time the resource exerts force on substrate during an escape jump.
Escape Jump Distance	m / R_n	negative	Distance animal travels in a single escape jump.
Escape Jump Force	N / R_n	negative	Force exerted on the substrate by a resource during an escape jump.
Escape Jump Rate	event / (R_n * s)	negative	Jump rate of a resource during escape locomotion.

Trait name	Trait unit	Motivation	Trait definition
Escape Stroke Length	m / R_n	negative	Distance covered by a resource in a single locomotory stroke during escape.
Escape Stroke Peak Force	N / R_n	negative	Force attained on the substrate by the resource during a locomotory stroke during escape.
Escape Stroke Peak Force Rate	N / (R_n * s)	negative	Rate of force attained on the substrate by the resource during a locomotory stroke during escape.
Escape Stroke Rate	event / (R_n * s)	negative	Rate of locomotory strokes of a resource during escape.
Escape Tail Beat Rate	event / (R_n * s)	negative	Rate of tail beats of a resource during escape burst locomotion.
Flee Distance	m / R_n	negative	Distance moved by a resource when fleeing a predator before stopping (includes escape burst component and other slower movement, if present).
Foraging Body Undulation Rate	event / (C_n * s)	positive	Rate of undulating body strokes used for feeding.
Foraging Gill Beat Rate	event / (C_n * s)	positive	Rate of beating cilia on gill of living consumer measured by direct examination of cilia.
Foraging Submersion Rate	event / (C_n * s)	voluntary	Rate consumer swims underwater while foraging.
Foraging Velocity	m / (C_n * s)	voluntary	Velocity of the whole consumer when foraging for food.
In Vitro Gill Beat Rate	event / s	autonomic	Rate of cilia beating on gill fragments removed from a living organism measured by direct examination of cilia.
In Vitro Gill Particle Transport Velocity	m / s	autonomic	Velocity of particles in grooves of gill fragments removed from a living organism.
Individual Length Growth Rate	m / (C_n* s)	autonomic	Rate of increase in length of an individual.
Individual Mass Growth Rate	kg / (C_n * s)	autonomic	Rate of increase in mass of an individual.
Population Voluntary Activity Probability	proportion	voluntary	Proportion of individuals in a population that are active (i.e., awake, not sleeping) at time of observation.

Trait name	Trait unit	Motivation	Trait definition
Population Voluntary Movement Probability	proportion	voluntary	Proportion of individuals in a population that are physically moving through space at time of observation.
Rattle Rate	event / (R_n * s)	negative	Rate of a rattlesnake's rattle.
Strike Acceleration	m / (C_n * s^2)	positive	Acceleration of a consumer's head during a strike at a resource.
Strike Completion Rate	event / (C_n * s)	positive	Rate a consumer completes a strike.
Strike Distance	m / C_n	positive	Distance between a consumer and resource when consumer initiates a strike per consumer.
Strike Velocity	m / (C_n * s)	positive	Velocity of a consumers strike per consumer (averaged over strike distance).
Subjugation-Consumption Body Contraction Rate	event / (C_n * s)	positive	Rate of body contractions for locomotion of a consumer during subjugation and consumption of resources.
Surface Area-Specific Foraging Gill Filtration Rate	m^3 / (m^2 * s)	positive	Area-specific volumetric flow rate of water across the surface-area of a gill of a filter feeding organism (flow rate measured directly, or by the clearance method where flow rate is estimated by the volume of water cleared of material per time).
Voluntary Activity Probability	proportion / C_n	voluntary	Probability that an organism is active at time of observation.
Voluntary Body Contraction Rate	event / (C_n * s)	voluntary	Rate of body contractions for locomotion in an organism with no apparent stimulus.
Voluntary Body Velocity	m / (C_n * s)	voluntary	Velocity of the whole organism during voluntary locomotion.
Voluntary Eye Saccade Angular Velocity	rad / (C_n * s)	voluntary	Angular velocity of fast eye movements, or saccade velocity, of an organism during voluntary activity.
Voluntary Movement Rate	event / (C_n * s)	voluntary	Rate organism physically moves through space.
Voluntary Stroke Rate	event / (C_n * s)	voluntary	Stroke rate of an organism during voluntary locomotion.
Voluntary Tail Beat Rate	event / (C_n * s)	voluntary	Rate of tail-beat cycles of an organism during voluntary locomotion.

Trait name	Trait unit	Motivation	Trait definition
Voluntary Tongue Flick Cycle Number	event / C_n	voluntary	Number of up-and-down motions or cycles of the tongue per flick in an organism with no obvious stimulus.
Voluntary Tongue Flick Cycle Rate	event / (C_n * s)	voluntary	Rate of up-and-down motions or cycles of the tongue per flick in an organism with no obvious stimulus.
Voluntary Tongue Flick Non-Cycle Rate	event / (C_n * s)	voluntary	Rate tongue is outside mouth and not moving in an organism with no obvious stimulus.
Voluntary Wing Beat Rate	event / (C_n * s)	voluntary	Rate of wing beating in a flying organism with no apparent stimulus.
Population			
Chlorophyll-a-Specific Carbon Production Rate	kg / (kg * s)	autonomic	Production rate of carbon by a primary producer, measured as mass of carbon produced per mass of chlorophyll-a.
Fecundity	1 / (C_n * s)	autonomic	Number of offspring produced by a female per time.
Mortality Rate	1 / (C_n * s)	autonomic	Number of deaths scaled by population size per time.
Population Density	C_n / A	autonomic	Number of individuals in the population per arena size.
Population Growth Rate	1 / (C_n * s)	autonomic	Intrinsic rate of population growth measured as individuals per individuals per time.
Radial Growth Rate	m / (C_n * s)	autonomic	Rate of increase in size (length, mass, or volume) of a population over time.
Interaction			
Attack Density Rate	event / ((R_n * C_n * s) / A)	positive	Rate of the completion of one attack to the start of the next attack per consumer standardized by arena size.
Attack Rate	event / (C_n * s)	positive	Rate of the completion of one attack to the start of the next attack per consumer.

Trait name	Trait unit	Motivation	Trait definition
Consumption Probability	proportion / C_n	positive	Probability that an active consumer will consume food offered to it.
Consumption Rate	event / (R_n * C_n * s)	positive	Rate of resources consumed per consumer.
Filtration Rate	m^3 / (C_n * s)	positive	Volumetric flow rate of water through a filter feeding consumer (flow rate measured directly, or by the clearance method as the volume of water cleared of material per time).
Foraging Behavior Probability	proportion / C_n	voluntary	Proportion of foraging time a consumer spends undertaking a particular foraging behavior within a subset of a single foraging bout.
Foraging Rate	event / (C_n * s)	voluntary	Length of a single foraging bout of a consumer.
Grazing Rate	m^2 / (C_n * s)	voluntary	The area grazed per consumer per time.
Handling Rate	R_n / (C_n * s)	positive	Rate at which consumer pursues, subjugates, and ingests resources (differs from attack rate because includes ingestion).
Host-Per-Parasitoid Parasitization Rate	event / ((R_n * C_n * s) / A)	positive	Rate of host parasitization per parasitoid standardized by arena size.
Intraspecific Confrontation Probability Density	proportion / (C_n / A)	voluntary	Proportion of time organism spends in intraspecific confrontations out of total observation time standardized by arena size.
Line Encounter Rate	event / s	voluntary	Encounter rate of individuals in a population moving past a fixed line.
Nest Provisioning Rate	R_n / (C_n * s)	positive	Rate resources bought back to the nest for consumption, by itself or its young, per consumer.
Point Encounter Density Rate	event / ((C_n * s) / A)	voluntary	Encounter rate of individuals in a population with an arbitrary point or line per consumer standardized by arena size.
Point Encounter Number Rate	event / (C_n * s)	voluntary	Encounter rate per consumer of individuals in a population with a fixed point or line.
Population Catchability	C_n / (R_n * s)	voluntary	Rate of resources caught in baited fishing traps per number of traps set.

Trait name	Trait unit	Motivation	Trait definition
Population Foraging Probability	proportion	voluntary	Proportion of consumer population that are foraging at time of observation.
Refuge Distance	m / R_n	negative	Distance to refuge for resource when initially spotted by a consumer (e.g., bush, rock, clump of grass).
Resource Habitat Encounter Density Rate	event / ((C_n * s) / A)	voluntary	Rate consumer encounters its resource habitat within the larger landscape per consumer standardized by arena size.
Resource Reaction Distance	m / R_n	negative	Distance from resource to consumer when resource apparently first reacts to approaching consumer (i.e., stops and/or moves away).
Resource Size Capture Intent Acceptance Probability	proportion / C_n	positive	Proportion of times that a 6 mg resource item was accepted when presented to a consumer after a captured 32 mg resource was taken.
Sediment Mass Processing Rate	kg / (C_n * s)	positive	Rate sediment mass is ingested and processed for food by a deposit feeder (most of what is ingested in non-digestible inorganic sediment).
Subjugation-through-Consumption Rate	event / (C_n * s)	positive	Rate resources are subdued and consumed per consumer.

Table S2. Q_{10} values associated with different 10°C ranges (10). Q_{10}'s are calculated over four temperature ranges (0-10, 0-20, 20-30, and 30-40°C) and then averaged across the full 0-40°C range for four activation energies, representing small (0.2 eV), median (0.55 eV), mean (0.65 eV), and large (1.2 eV) activation energies.

Temp. Range (°C)	0.2 eV	0.55 eV	0.65 eV	1.2 eV
0-10	1.34	2.28	2.65	6.05
10-20	1.32	2.15	2.48	5.35
20-30	1.29	2.05	2.33	4.79
30-40	1.27	1.95	2.21	4.33
0-40	1.31	2.11	2.42	5.13

Table S3. Summary of intraspecific thermal responses used in our analysis. Data are listed in alphabetical order by traits and then taxa. Trait names correspond to those in Table S1. Taxa names represent the lowest level of taxonomy given in the original source (typically species), followed by life stage and sex when present (in square parenthesis), and trophic designation (P, producer; H, herbivore; O, omnivore; C, carnivore; D, detritivore; S, non-feeding organisms, such as eggs, pupae, etc). For interaction traits, consumer and resource are separated by an arrow (consumer is on the left). Artificial "taxa", such as light as a resource for photosynthesis or pressure waves as a consumer for escape body velocity, are appropriately designated and are not assigned a trophic group. **Cit** is citation code (Table S6); **H** is habitat (M, marine; F, freshwater; T, terrestrial); **LF** is whether the setting was laboratory (L) or field (F); **Temp** is minimum and maximum temperatures over which the response was measured; **P** is the number of distinct temperature points. $\boldsymbol{E_R}$ and $\boldsymbol{E_F}$ are estimated activation energies of the rise and fall components of the temperature responses, calculated from fits to the Boltzmann-Arrehnius model. $\boldsymbol{Q_{10\,R}}$ and $\boldsymbol{Q_{10\,F}}$ are estimated Q_{10} values of the rise and fall components of the temperature responses. NS are non-significant fits; $\boldsymbol{T_{opt}}$ are estimates of optimal temperatures. See Materials and Methods (main text) and SI for details on how these values were calculated. Blank cells in the Trait/Consumer-Resource columns signify that the trait and taxa are the same as the last non-blank cell above in the same column. Blank cells in all other columns indicate that the quantity could not be calculated for that response or was not measurable.

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	**Cit**	**Hab**	**L/F**	**Temp**	**N**	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
48-hr Hatching Probability (individual)										
Acartia sinjiensis [adult] O –> microalgae P	125	M	L	10–38	8	0.66	2.42			34
Ammonia Excretion Rate (internal)										
Dreissena polymorpha [adult] O	2	F	L	20–32	4	1.1	4.17			
Attack Density Rate (species interaction)										
Perca flavescens [juvenile] O –> Coregonus clupeaformis [juvenile] C	190	F	L	5–18	4					10
	190	F	L	5–18	4					15
Perca fluviatilis [adult] O –> Chaoborus obscuripes [juvenile] C	140	F	L	12–21	4			NS	NS	
Rutilus rutilus [adult] O –> Chaoborus obscuripes [juvenile] C	140	F	L	12–21	4			NS	NS	
Attack Rate (species interaction)										
Cicindela hybrida [adult] C –> cursorial insects	42	T	F	23–40.3	8	0.66	2.33			34.7
Avoidance Body Velocity (individual)										
gravity –> Aphidius ervi [adult] C	60	T	L	12–36	7	0.9	3.37			28
	60	T	L	12–36	7	0.92	3.47			28
light –> Homarus americanus [adult] C	120	M	L	10–28	5	NS	NS			25
	120	M	L	2–15	4					5
	120	M	L	2–20	5					10

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	120	M	L	2–25	6					12.5
	120	M	L	2–25	6	NS	NS			20
	120	M	L	5–25	5					20
Bite Rate (individual)										
Cellana ornata [adult] H –> microalgae P	21	M	F	7.3–17.3	12	0.52	2.08			
Hyles lineata [juvenile] H –> desert plants P	27	T	F	13.7–34	5	0.43	1.77			
Littorina littorea [adult] H –> epiphytic micro-organisms O	133	M	L	5–25	5	0.4	1.76			
Manduca sexta [juvenile] H –> Datura inoxia P	27	T	F	13.1–31.8	7	0.51	1.96			
Chlorophyll-a-Specific Carbon Production Rate (population)										
Periphyton P	93	F	L	3–21	7	0.49	1.99			
Consumption Probability (species interaction)										
Pituophis catenifer affinis [adult] C –> Mus musculus [adult] O	65	T	L	18–33	4	NS	NS			
Consumption Probability (species interaction)										
Uta stansburiana [adult] C –> Acheta sp. A [adult] O	178	T	L	20–36	6	NS	NS			32
	178	T	L	20–36	6	NS	NS			32
Consumption Rate (species interaction)										
Acroneuria californica [juvenile] O –> Hydropsyche spp. [juvenile] O	75	F	L	14–28	8	0.33	1.57			26
	75	F	L	16–28	7	0.42	1.74			
	75	F	L	6–20	7	0.62	2.42			18
Acroneuria californica [juvenile] O –> Simulium spp. [juvenile] O	75	F	L	10–24	8			0.12	0.85	12
	75	F	L	10–24	8	0.15	1.22			
	75	F	L	18–30	6	NS	NS	NS	NS	
Agonum dorsale [adult] C –> Sitobion avenae [juvenile] H	162	T	L	12.3–23.6	4	1.15	4.79			
Bembidion lampros [adult] C –> Rhopalosiphum padi [adult] H	31	T	L	10–25	4	0.72	2.7			
Bembidion lampros [adult] C –> Rhopalosiphum padi [juvenile] H	31	T	L	10–25	4					25
Bembidion lampros [adult] C –> Sitobion avenae [juvenile] H	162	T	L	12.3–23.6	4					20.6
Bembidion obtusum [adult] C –> Sitobion avenae [juvenile] H	162	T	L	12.3–23.6	4	NS	NS			
Carcinops pumilio [adult] C –> Musca domestica [juvenile] D	59	T	L	15–33	4	0.8	2.87			
Carcinus maenas [adult] O –> Mytilus edulis [adult] O	179	M	L	3.8–17.7	4	0.77	3.05			
	179	M	L	6.9–18.4	6	NS	NS			16.3
Celithemis fasciata [juvenile] C –> Chironomus tentans [juvenile] O	66	F	L	10–25	4					15
	66	F	L	10–25	4					20

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	66	F	L	10–25	4	0.85	3.2			
	66	F	L	10–25	4	NS	NS			
	66	F	L	10–25	4	NS	NS			
Chaoborus americanus [juvenile] C –> Diaptomus kenai [adult] O	50	F	L	5–20	4	0.68	2.63			
	50	F	L	5–20	4	NS	NS			
Chaoborus americanus [juvenile] C –> Diaptomus tyrelli [adult] O	50	F	L	5–20	4	NS	NS			
Chaoborus trivittatus [juvenile] C –> Diaptomus kenai [adult] O	50	F	L	5–20	4					15
	50	F	L	5–20	4	NS	NS			
	50	F	L	5–20	4	NS	NS			
Chaoborus trivittatus [juvenile] C –> Diaptomus tyrelli [adult] O	50	F	L	5–20	4	0.69	2.66			
Cicindela hybrida [adult] C –> cursorial insect	42	T	F	19.9–39.9	5					29.9
Dreissena polymorpha [adult] O –> Chlorella spp. P	2	F	L	20–32	4					24
Gymnocephalus cernuus [adult] C –> Chaoborus obscuripes [juvenile] C	18	F	L	4–20	5	0.16	1.25			
	18	F	L	4–20	5	0.4	1.76			
	18	F	L	4–20	5	NS	NS			
	18	F	L	4–20	5	NS	NS			
Harpalus rufipes [adult] C –> Sitobion avenae [juvenile] H	162	T	L	12.3–23.6	4	0.89	3.38			
Ischnura elegans elegans [juvenile] C –> Daphnia magna [adult] O	171	F	L	5–27.5	6			NS	NS	12
	171	F	L	5–27.5	6	0.59	2.33			16
	171	F	L	5–27.5	6	NS	NS			16
	171	F	L	5–27.5	6	NS	NS			16
	171	F	L	5–27.5	6	NS	NS			16
	171	F	L	5–27.5	6	NS	NS			16
	171	F	L	5–27.5	6	NS	NS			16
	171	F	L	5–27.5	7	0.97	4			16
	171	F	L	5–27.5	8	NS	NS			
Macrocheles muscaedomesticae [adult] C –> Musca domestica [juvenile] D	59	T	L	15–33	4	0.85	3.06			
Naucoris congrex [adult] C –> Culicidae spp. [juvenile] O	118	F	L	5–25	4					20
	118	F	L	5–25	4	0.52	2.07			
	118	F	L	5–25	4	0.53	2.1			
	118	F	L	5–25	4	0.57	2.23			
	118	F	L	5–25	4	0.58	2.24			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\ R}$	E_F	$Q_{10\ F}$	T_{opt}
	118	F	L	5–25	4	0.6	NS			
	118	F	L	5–25	4	NS	NS			
Notonecta glauca [adult] C –> Asellus aquaticus [adult] O	34	F	L	5–20	4					10
	34	F	L	5–25	5					15
Notonecta glauca [adult] C –> Culex pipiens [juvenile] O	34	F	L	5–25	5	0.76	2.86			
	34	F	L	5–25	5	1.1	4.76			20
Notonecta hoffmani [adult] C –> Culex pipiens [juvenile] O	129	F	L	10–25	4	1.1	4.54			
Nucella lapillus [adult] C –> Mytilus edulis [adult] O	99	M	L	3–25	8	0.91	3.65			
Orius insidiosus [adult] C –> Panonychus ulmi [adult] H	117	T	L	18.3–35	4					29.4
	117	T	L	18.3–35	4					29.4
	117	T	L	18.3–35	4	0.72	2.55			
	117	T	L	18.3–35	4	NS	NS			
	117	T	L	18.3–35	4	NS	NS			
Parus major [adult] O –> Zygiella x-notata [adult] C	7	T	L	2.9–12.7	6	NS	NS			
Perca flavescens [juvenile] O –> Coregonus clupeaformis [juvenile] C	190	F	L	5–18	4					15
	190	F	L	5–18	4					18
Perca fluviatilis [adult] O –> Chaoborus obscuripes [juvenile] C	18	F	L	4–20	5					16
	18	F	L	4–20	5	0.8	3.11			
	18	F	L	4–20	5	0.99	4.21			16
	18	F	L	4–20	5	NS	NS			16
	18	F	L	4–20	5	NS	NS			16
	18	F	L	4–20	5	NS	NS			16
	140	F	L	12–21	4	0.46	1.88			
	140	F	L	12–21	4	0.53	NS			
	140	F	L	12–21	4	NS	NS			
	140	F	L	12–21	4	NS	NS			
	140	F	L	12–21	4	NS	NS			
	140	F	L	12–21	4	NS	NS			
Phytoseiulus persimilis [adult] C –> Tetranychus urticae [adult] H	48	T	L	15–30	4					25
	48	T	L	15–30	4	0.46	1.83			
	48	T	L	15–30	4	0.63	2.31			
	48	T	L	15–30	4	0.65	2.37			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	48	T	L	15–30	4	0.74	2.67			
	48	T	L	15–30	4	0.85	3.07			
Polinices duplicatus [adult] C –> Mya arenaria [adult] O	45	M	F	9.5–23	4	1.14	5.26			22.8
Porotermes adamsoni [adult] D –> Eucalyptus regnans [adult] P	105	T	L	11.5–24	4	0.74	2.75			
Porotermes adamsoni [adult] D –> Eucalyptus viminalis [adult] P	105	T	L	11.5–24	4	0.65	2.42			
Porotermes adamsoni [adult] D –> Pinus radiata [adult] P	105	T	L	9–26	5	0.77	2.86			
Ranatra dispar [adult] C –> Anisops deanei [adult] C	10	F	L	15–30	4	0.51	1.97			
	10	F	L	15–30	4	0.56	NS			
	10	F	L	15–30	4	NS	NS			
	10	F	L	15–30	4	NS	NS			
Rutilus rutilus [adult] O –> Chaoborus obscuripes [juvenile] C	140	F	L	12–21	4	0.77	2.89			
	140	F	L	12–21	4	0.86	3.28			
	140	F	L	12–21	4	0.86	3.27			
	140	F	L	12–21	4	0.92	3.55			
	140	F	L	12–21	4	0.93	3.62			
	140	F	L	12–21	4	NS	NS			
Salvelinus malma [juvenile] C –> dead Euphausia superba [adult]	93	F	L	3–21	7	NS	NS	2.4	0.04	12
Stethorus punctum [adult] O –> Panonychus ulmi [adult] H	82	T	L	21–32.5	5	0.53	1.99			
	82	T	L	21–32.5	5	0.58	2.13			
	82	T	L	21–32.5	5	0.61	2.21			31
	82	T	L	21–32.5	5	0.93	3.36			31
	82	T	L	21–32.5	5	NS	NS			31
Tachyporus hypnorum [adult] C –> Sitobion avenae [juvenile] H	162	T	L	12.3–23.6	4					20.6
Thais haemastoma [adult] C –> Crassostrea virginica [juvenile] O	58	M	L	10–30	6	NS	NS			
Urosalpinx cinerea [adult] C –> Crassostrea virginica [juvenile] O	70	M	L	8.3–30	5	1.18	5.1			25
Urosalpinx cinerea [adult] C –> Mytilus edulis [juvenile] O	70	M	L	10–30	5	NS	NS			25
Critical Holding Velocity (individual)										
electric shock –> Salmo salar [juvenile] C	63	F	L	3.1–14.6	7	0.31	1.6			9.6
	63	F	L	3.1–14.6	7	0.56	2.29			9.6
Critical Travel Velocity (individual)										
electric shock –> Barbus barbus [adult] O	135	F	L	7–25	4					19
	135	F	L	7–25	4	NS	NS			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
electric shock –> Cyprinella spiloptera [juvenile] O	78	F	L	15–35	5	0.53	2.01			30
electric shock –> Exodon paradoxus [adult] C	15	F	L	20–35	4					30
electric shock –> Leporinus fasciatus [adult] O	15	F	L	25–37	4					35
electric shock –> Micropterus salmoides [juvenile] C	78	F	L	15–35	5	0.24	1.37			30
electric shock –> Oncorhynchus nerka [juvenile] C	22	F	L	5–27.5	7			NS	NS	20
electric shock –> Puntius schwanenfeldii [adult] O	135	F	L	17–30	4					25
	135	F	L	20–33	4					30
light –> Micropterus dolomieu [juvenile] C	100	F	L	10–30	5	0.31	1.52			
	100	F	L	10–30	5	0.43	1.77			
	100	F	L	10–30	5	0.56	2.16			25
	100	F	L	5–20	4	0.53	2.13			
	100	F	L	5–25	5	0.53	2.12			20
retaining screen –> Ictalurus punctatus [juvenile] O	78	F	L	15–35	5	NS	NS			30
Critical Upright Time (individual)										
Homo sapiens [adult] O –> Natrix maura [adult] C	68	T	L	10–35	6	0.48	1.91			30
Development Rate (individual)										
Aphis gossypii H –> Cucumis sativus P	191	T	L	10–30	5	0.6	2.26			
Bactrocera correcta [egg] S	112	T	L	18–36	5	0.48	1.88			33
Bactrocera correcta [pupae] S	112	T	L	18–36	5	0.45	1.78			
	112	T	L	18–36	5	0.44	1.78			33
Cherax quadricarinatus [juvenile] O –> crayfish ration	121	F	L	16–32	9	0.8	2.89			28
Chinemys reevesii [egg] S	43	F	L	24–34	6	0.29	1.44			
Cydia pomonella [egg] S	1	T	L	14–33	6	0.76	2.74			30
Cydia pomonella [juvenile] H –> artificial diet	1	T	L	14–33	6	0.76	2.8			27
Cydia pomonella [pupae] S	1	T	L	14–33	6	0.77	2.77			30
Euplectrus ronnai [juvenile] C –> Pseudaletia sequax [juvenile] H	189	T	L	15–29	5	0.79	2.88			
Euplectrus ronnai [pupae] S –> Pseudaletia sequax [juvenile] H	189	T	L	15–29	5	0.91	3.34			
Glyptapanteles muesebecki [juvenile] C –> Pseudaletia sequax [juvenile] H	54	T	L	14–29	6	0.72	2.64			26
Glyptapanteles muesebecki [pupae] S –> Pseudaletia sequax [juvenile] H	54	T	L	14–29	6	0.82	2.98			
Macrocentrus iridescens [juvenile] C –> Choristoneura rosaceana [juvenile] H	97	T	L	13.9–31	6	0.74	2.72			25.8
Planococcus citri [egg] S –> Solenostemon scutellarioides P	61	T	L	15–32	8	0.72	2.59	NS	NS	25
	61	T	L	18–32	7	1.2	4.96	NS	NS	25

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Planococcus citri [juvenile] H –> Solenostemon scutellarioides P	61	T	L	15–32	8	0.93	3.51	0.49	0.53	25
	61	T	L	18–32	7	0.46	1.83			
Planococcus citri [pupae] H –> Solenostemon scutellarioides P	61	T	L	18–32	7	0.84	3.02	NS	NS	25
	61	T	L	18–32	7	1.03	3.86	NS	NS	25
Procambarus clarkii [adult] O –> uncooked mixed vegetables	30	F	L	15–30	6	0.65	2.38			
Procambarus clarkii [juvenile] O –> uncooked mixed vegetables	30	F	L	15–30	6	0.54	2.05			
Sitona discoideus [egg] S	5	T	L	8.5–30	8	0.67	2.48			28
Telenomus chrysopae [juvenile] C –> Chrysoperla rufilabris [egg] S	155	T	L	15.6–26.7	5	0.85	3.14			
	155	T	L	15.6–26.7	5	0.91	3.36			
Telenomus isis [juvenile] C –> Busseola fusca [egg] S	25	T	L	18–32	6	0.61	2.21			30
	25	T	L	18–32	6	0.64	2.31			30
Telenomus isis [juvenile] C –> Sesamia calamistis [egg] S	25	T	L	18–32	6	0.57	2.13			30
	25	T	L	18–32	6	0.59	2.18			30
Telenomus isis [juvenile] C –> Sesamia nonagrioides [egg] S	25	T	L	18–32	6	0.59	2.16			30
	25	T	L	18–32	6	0.64	2.32			30
Telenomus lobatus [juvenile] C –> Chrysoperla rufilabris [egg] S	155	T	L	15.6–26.7	5	0.89	3.31			
Tetraneura nigri abdominalis [juvenile] H –> Oryza sativa P	98	T	L	10–35	6	0.64	2.39			30
Theocolax elegans [juvenile] C –> Sitophilus zea-mais [egg] S	84	T	L	20–35	6	0.79	2.79			32
	84	T	L	20–35	6	0.81	2.86			32
Trichogramma bruni [juvenile] C –> Corcyra cephalonica [egg] S	90	T	L	15–32	6	0.6	2.23			30
	90	T	L	20–32	5	NS	NS			30
Trichogramma sp. nr. lutea [juvenile] C –> Corcyra cephalonica [egg] S	90	T	L	15–32	6	0.47	1.84			
	90	T	L	15–32	6	0.56	2.09			30
	90	T	L	15–32	6	0.57	2.13			30
	90	T	L	15–32	6	0.65	2.38			28
	90	T	L	15–35	7	0.41	1.71			
	90	T	L	15–35	7	0.43	1.75			
Trichogramma sp. nr. mwanzai [juvenile] C –> Corcyra cephalonica [egg] S	90	T	L	15–32	6	0.59	2.17			30
	90	T	L	15–32	6	0.64	2.34			30
	90	T	L	15–35	7	0.42	1.73			
	90	T	L	15–35	7	0.48	1.86			

Digestion Rate (internal)

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Perca fluviatilis [adult] O –> Gammarus pulex [adult] O	139	F	L	4–21.7	7	1.07	4.64			
Ptychocheilus oregonensis [adult] C –> Oncorhynchus mykiss [juvenile] C	163	F	L	6–24	5	0.88	3.4			
	163	F	L	6–24	5	1.05	4.33			
	163	F	L	6–24	5	1.26	5.8			
Salmo trutta [adult] C –> dead Hydropsyche spp. [juvenile]	47	F	L	5.2–15	4	0.77	3.06			
	47	F	L	5.2–15	4	0.77	3.06			
	47	F	L	5.2–15	4	0.77	3.05			
	47	F	L	5.2–15	4	0.78	3.07			
Salmo trutta [adult] C –>dead invertebrate	47	F	L	5.2–15	5	0.77	3.06			
	47	F	L	5.2–15	5	0.77	3.07			
	47	F	L	5.2–15	5	0.78	3.07			
	47	F	L	5.2–15	5	0.78	3.1			
Salmo trutta [adult] C –> dead Protonemura meyeri [juvenile]	47	F	L	5.2–15	5	0.73	2.88			
	47	F	L	5.2–15	5	0.74	2.91			
	47	F	L	5.2–15	5	0.74	2.9			
	47	F	L	5.2–15	5	0.74	2.91			
Salmo trutta [adult] C –> Tenebrio molitor [juvenile] H	47	F	L	5.2–15	5	0.77	3.06			
	47	F	L	5.2–15	5	0.77	3.06			
	47	F	L	5.2–15	5	0.77	3.06			
	47	F	L	5.2–15	5	0.78	3.07			
Thamnophis elegans vagrans [adult] C –> Mus musculus [adult] O	167	T	L	9.8–35	10	1.06	4.19	NS	NS	24.8
Endurance Time (individual)										
Homo sapiens [adult] O –> Sceloporus undulatus [adult] O	4	T	L	11.4–40.6	9	0.33	1.54			33
Escape Angle of Body Turning (individual)										
prodding with a probe –> Myoxocephalus scorpius [adult] C	170	M	L	0.8–20	4					5
	170	M	L	0.8–20	4			NS	NS	
	170	M	L	0.8–20	4			NS	NS	
prodding with a probe –> Taurulus bubalis [adult] C	170	M	L	0.8–20	4					5
Escape Angular Rate of Body Turning (individual)										
pressure waves –> Carassius auratus [adult] O	87	F	L	10–40	5					40
	87	F	L	5–30	5					25
pressure waves –> Fundulus heteroclitus [adult] O	87	F	L	5–30	5					25

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
prodding with a probe –> Myoxocephalus scorpius [adult] C	170	M	L	0.8–20	4	NS	NS			
prodding with a probe –> Taurulus bubalis [adult] C	170	M	L	0.8–20	4					5
	170	M	L	0.8–20	4					5
Escape Body Acceleration (individual)										
electric shock –> Danio rerio [juvenile] O	56	F	L	21.1–30	7	NS	NS			
Homo sapiens [adult] O –> Phelsuma dubia [adult] O	19	T	L	15–35	5	0.39	1.69			30
prodding with a probe –> Myoxocephalus scorpius [adult] C	170	M	L	0.8–20	4					15
	170	M	L	0.8–20	4					15
prodding with a probe –> Taurulus bubalis [adult] C	170	M	L	0.8–20	4					15
	170	M	L	0.8–20	4	NS	NS			
Escape Body Deceleration (individual)										
Homo sapiens [adult] O –> Phelsuma dubia [adult] O	19	T	L	15–35	5	0.36	1.61			30
Escape Body Power Production (individual)										
electric shock –> Rana pipiens [adult] C	77	T	L	14–30	4					25
Homo sapiens [adult] O –> Phelsuma dubia [adult] O	19	T	L	15–35	5	0.5	1.91			
Escape Body Response Rate (individual)										
pressure waves –> Calanus finmarchicus [adult] O	106	M	L	3.7–15.4	11	0.33	1.62			14.5
Escape Body Velocity (individual)										
electric shock –> Danio rerio [juvenile] O	56	F	L	21–30	4	0.18	1.26			
	56	F	L	21–30	4	0.25	1.38			
electric shock –> Necturus maculosus [adult] C	126	F	L	5–25	5					15
electric shock –> Xenopus laevis [adult] C	126	F	L	10–30	7	0.25	1.4			27
Homo sapiens [adult] O –> Acanthodactylus erythrurus [adult] C	14	T	L	25.4–40.4	6	0.21	1.3			
Homo sapiens [adult] O –> Agama savignyi [adult] C	76	T	L	18–42	7	0.5	1.92			34
Homo sapiens [adult] O –> Bufo boreas [adult] C	143	T	L	3.8–27.9	5	0.61	2.33			
Homo sapiens [adult] O –> Bufo woodhousii woodhousii [adult] C	113	T	L	15–30	4					30
	113	T	L	15–30	4					30
Homo sapiens [adult] O –> Coleonyx brevis [adult] C	81	T	L	20–40	6	0.24	1.35			37.5
Homo sapiens [adult] O –> Coleonyx variegatus [adult] C	81	T	L	15–40	7	0.28	1.43			
Homo sapiens [adult] O –> Hemidactylus frenatus [adult] C	81	T	L	15–39.5	7	0.46	1.83			34
Homo sapiens [adult] O –> Hemidactylus turcicus [adult] C	81	T	L	20–40	6	0.25	1.37			38.8
Homo sapiens [adult] O –> Iberolacerta monticola [adult] C	14	T	L	26.6–40	6	NS	NS			34.9

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Homo sapiens [adult] O –> Lacerta agilis [adult] C	14	T	L	25.9–39.5	6	0.38	1.61			37.7
Homo sapiens [adult] O –> Lacerta schreiberi [adult] C	14	T	L	24.8–40.4	6	0.3	1.47			35.9
Homo sapiens [adult] O –> Lepidodactylus lugubris [adult] O	81	T	L	15–36.5	6	0.33	1.53			
Homo sapiens [adult] O –> Natrix maura [adult] C	68	T	L	4.2–34.1	7	0.63	2.35			
	68	T	L	5.7–35.6	7	0.62	2.28			
Homo sapiens [adult] O –> Phelsuma dubia [adult] O	19	T	L	15–35	5	0.33	1.53			
Homo sapiens [adult] O –> Podarcis bocagei [adult] O	14	T	L	26.2–39.7	6	0.42	1.7			35
Homo sapiens [adult] O –> Podarcis hispanica [adult] O	14	T	L	26.1–40.2	6	0.5	1.88			37.5
	14	T	L	26–39.5	6	0.47	1.8			37.3
Homo sapiens [adult] O –> Podarcis lilfordi [adult] O	14	T	L	26.1–39.9	6	0.32	1.48			37.3
Homo sapiens [adult] O –> Podarcis muralis [adult] O	14	T	L	25.1–39.6	6	0.3	1.45			35.2
Homo sapiens [adult] O –> Podarcis tiliguerta [adult] O	175	T	L	20–37.5	7	0.3	1.46			
	175	T	L	20–37.5	7	0.31	1.49			
Homo sapiens [adult] O –> Psammodromus algirus [adult] C	14	T	L	24.5–39.8	6	0.36	1.57			34.7
Homo sapiens [adult] O –> Psammodromus hispanicus [adult] C	14	T	L	25.8–39.5	6	0.48	1.83			34.5
Homo sapiens [adult] O –> Rana pipiens [adult] C	143	T	L	4.4–29.1	5	0.33	1.57			
Homo sapiens [adult] O –> Sceloporus occidentalis [adult] O	116	T	L	9.9–39.5	9	0.63	2.27			35.3
Homo sapiens [adult] O –> Sceloporus undulatus [adult] O	4	T	L	11.3–40.5	9	0.44	1.76			36
Homo sapiens [adult] O –> Scincella lateralis [adult] C	159	T	L	19.5–38	5	0.29	1.45			33.5
Homo sapiens [adult] O –> Thamnophis elegans vagrans [adult] C	167	F	L	5.4–35.6	7	0.36	1.63			30.5
	167	F	L	5.6–35.7	7	0.38	1.68			30.7
	167	T	L	3.9–34	7	0.71	2.61			
	167	T	L	3.9–34.1	7	0.55	2.1			
Homo sapiens [adult] O –> Thamnophis sirtalis [adult] C	73	T	L	15.5–30.6	5	0.57	2.12			
	73	T	L	16.2–32.4	11	0.51	1.94			
	73	T	L	16.8–30.6	5	0.6	2.23			26.3
	73	T	L	16.8–31.5	5	0.57	2.11			
	73	T	L	16.9–31.2	5	NS	NS			
	73	T	L	17.1–31.2	5	0.68	2.48			31.2
pressure waves –> Barbus barbus [adult] O	135	F	L	7–25	4					25
	135	F	L	7–25	4	0.19	1.31			
pressure waves –> Carassius auratus [adult] O	87	F	L	10–40	5					35

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	87	F	L	10–40	5	NS	NS			35
	87	F	L	5–30	5					15
	87	F	L	5–30	5	0.2	NS			25
pressure waves –> Fundulus heteroclitus [adult] O	87	F	L	5–30	5					20
	87	F	L	5–30	5					20
prodding with a probe –> Clupea harengus [juvenile] H	12	M	L	4.7–17.5	22	0.2	1.34			
	12	M	L	4.9–17.2	13	0.29	1.52			
prodding with a probe –> Cnemidophorus murinus [adult] C	17	T	L	20–43.5	6	NS	NS			40
	17	T	L	20–44	6	0.51	NS			40
	17	T	L	20–44	6	NS	NS			40
prodding with a probe –> Dipsosaurus dorsalis [adult] H	17	T	L	15–43.5	7	0.89	3.1			40
	17	T	L	15–44	7	0.85	3			35
	17	T	L	15–44	7	0.96	3.48			35
prodding with a probe –> Elgaria multicarinata [adult] C	17	T	L	10–37.5	7	0.44	1.82			30
	17	T	L	10–37.5	7	0.5	1.92			
	17	T	L	10–37.5	7	0.52	2.02			30
prodding with a probe –> Myoxocephalus scorpius [adult] C	170	M	L	0.8–20	4					15
	170	M	L	0.8–20	4					15
prodding with a probe –> Sceloporus occidentalis [adult] O	17	T	L	10–40	5	0.54	2.03			
	17	T	L	10–40	7	0.38	1.64			35
	17	T	L	10–40	7	0.46	1.84			35
	17	T	L	10–40	7	0.51	1.92			
prodding with a probe –> Taurulus bubalis [adult] C	170	M	L	0.8–20	4					15
	170	M	L	0.8–20	4	NS	NS			
prodding with a probe –> Uma inornata [adult] C	17	T	L	20–43.5	7	0.24	1.35			40
Escape Body Velocity Probability (individual)										
prodding with a probe –> Conolophus pallidus [juvenile] O	32	T	F	15–39.3	5	NS	NS			33.5
	32	T	F	17–39.5	10	0.72	2.53			34.4
	32	T	F	20.4–39.8	4					39.8
prodding with a probe –> Uta stansburiana [adult] C	177	T	L	15–38.5	4					33.5
	177	T	L	15–41.9	9	0.39	1.65			37.9
	177	T	L	19.9–39.9	6	1.27	5			38

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Escape Gait Change Velocity (individual)										
electric shock –> Uromastyx aegyptia [adult] H	41	T	L	35.1–44	7			4.28	0.01	
Escape Jump Contact Rate (individual)										
electric shock –> Rana pipiens [adult] C	77	T	L	14–30	4	0.29	1.47			
Escape Jump Distance (individual)										
electric shock –> Rana pipiens [adult] C	77	T	L	14–30	4					18
	77	T	L	14–30	4					25
	77	T	L	14–30	4					25
	77	T	L	14–30	4	0.35	1.61			
	77	T	L	14–30	4	NS	NS			
	77	T	L	14–30	4	NS	NS			
Homo sapiens [adult] O –> Bufo woodhousii woodhousii [adult] C	113	T	L	15–30	4					30
	113	T	L	15–30	4	0.24	1.38			
Homo sapiens [adult] O –> Rana clamitans [adult] C	80	T	L	5–30	7	0.25	1.43			20
prodding with a probe –> Acris crepitans [adult] C	96	T	L	5–30	6	0.2	1.31			
prodding with a probe –> Bufo americanus [adult] C	146	T	L	5–25	5	0.13	1.2			
	146	T	L	5–25	5	NS	NS			
prodding with a probe –> Bufo woodhousii woodhousii [adult] C	113	T	L	15–30	4					25
	113	T	L	15–30	4	0.21	1.31			
prodding with a probe –> Hyla femoralis [adult] C	96	T	L	5–30	6	0.2	1.32			
prodding with a probe –> Limnodynastes tasmaniensis [adult] C	184	T	L	4.4–33.2	6	NS	NS			29.5
	184	T	L	4.4–35.7	7	0.33	1.58			29.5
prodding with a probe –> Pseudacris triseriata [adult] C	96	T	L	5–30	6	0.13	1.29			
	96	T	L	5–30	6	0.15	1.23			
prodding with a probe –> Rana clamitans [adult] C	96	T	L	5–30	6	0.33	1.59			25
prodding with a probe –> Rana pipiens [adult] C	146	T	L	5–25	5	0.38	1.71			
	146	T	L	5–25	5	NS	NS			
prodding with a probe –> Rana sylvatica [adult] C	96	T	L	5–30	6	0.26	1.43			
	96	T	L	5–30	6	0.29	1.49			
Escape Jump Force (individual)										
electric shock –> Rana pipiens [adult] C	77	T	L	14–30	4					25
Escape Jump Rate (individual)										

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Homo sapiens [adult] O –> Bufo woodhousii woodhousii [adult] C	113	T	L	15–30	4					20
	113	T	L	15–30	4					25
Escape Stroke Length (individual)										
Homo sapiens [adult] O –> Phelsuma dubia [adult] O	19	T	L	15–35	5	0.18	1.27			
Homo sapiens [adult] O –> Sceloporus occidentalis [adult] O	116	T	L	9.9–39.6	9	0.11	1.16			
Escape Stroke Peak Force (individual)										
pressure waves –> Calanus finmarchicus [adult] O	106	M	L	3.8–15.4	11	0.23	1.41			
Escape Stroke Peak Force Rate (individual)										
	106	M	L	4.5–14.6	8	0.44	1.89			
Escape Stroke Rate (individual)										
Homo sapiens [adult] O –> Atelopus muisca [adult] C	130	F	F	5–25	5					10
Homo sapiens [adult] O –> Atelopus sp. nov. [adult] C	130	F	F	5–25	5					15
Homo sapiens [adult] O –> Atelopus varius [adult] C	130	F	F	5–30	6	0.37	1.68			27.5
Homo sapiens [adult] O –> Colostethus flotator [adult] C	130	F	F	14.6–30	4					20
Homo sapiens [adult] O –> Colostethus subpunctatus [adult] C	130	F	F	5–25	5					15
Homo sapiens [adult] O –> Colostethus talamancae [adult] C	130	F	F	10–30	5					25
Homo sapiens [adult] O –> Eleutherodactylus bogotensis [adult] C	130	F	F	5–25	5					15
Homo sapiens [adult] O –> Eleutherodactylus diastema [adult] C	130	F	F	10–30	5					25
Homo sapiens [adult] O –> Hyla ebraccata [adult] C	130	F	F	5–30	6	NS	NS			25
Homo sapiens [adult] O –> Hyla labialis [adult] C	130	F	F	5–25	5	NS	NS			
Homo sapiens [adult] O –> Hyla microcephala [adult] C	130	F	F	9.7–30	5	NS	NS			25
Homo sapiens [adult] O –> Phelsuma dubia [adult] O	19	T	L	15–35	5	0.26	1.41			
Homo sapiens [adult] O –> Sceloporus occidentalis [adult] O	116	T	L	10.3–39.7	9	0.48	1.87			35.4
pressure waves –> Calanus finmarchicus [adult] O	106	M	L	3.6–15.3	11	0.23	1.4			
	106	M	L	4.9–14.8	13	0.38	1.75			
Escape Tail Beat Rate (individual)										
prodding with a probe –> Clupea harengus [juvenile] H	12	M	L	4.6–17.4	22	0.4	1.78			
	12	M	L	5–17.1	11	0.38	1.72			17
Faecal Excretion Rate (internal)										
Hexagenia limbata [juvenile] H –> sediment 'a'	192	F	L	5–25	5	0.31	1.55			
	192	F	L	5–25	5	0.37	1.69			
	192	F	L	5–25	5	0.43	1.84			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Fecundity (population)										
Tetraneura nigri abdominalis [adult] H –> Oryza sativa P	98	T	L	10–35	6	1.37	6.27			30
Feeding Heart Beat Rate (internal)										
Crassostrea virginica [adult] O	51	M	L	10–21.9	4	0.75	2.84			
	51	M	L	10–21.9	4	0.89	3.6			
	51	M	L	10–22	4					17.9
	51	M	L	10–22	4					17.9
	51	M	L	10–22	4	0.92	3.58			
	51	M	L	10–22	4	1.26	5.73			
	51	M	L	4.8–39.5	6	0.5	1.97			34.7
	51	M	L	4.8–40.1	6	NS	NS			29.8
	51	M	L	4.9–39.7	6	NS	NS			29.5
	51	M	L	4.9–40.1	6	0.56	2.14			29.8
	51	M	L	5.1–39.9	6	NS	NS			30
	51	M	L	5.2–39.9	6	0.24	1.38			35
	51	M	L	5.2–39.9	6	0.6	2.2			
	51	M	L	5.3–40	6	0.79	NS			30
	51	M	L	5.3–40.1	6	0.66	NS			29.9
	51	M	L	9.8–22	4	0.67	2.54			
	51	M	L	9.9–21.9	4	0.88	3.4			
	51	M	L	9.9–22	4	0.85	3.24			
	51	M	L	9.9–22	4	0.92	3.57			
Mytilus edulis [adult] O	185	M	L	10–25	4	0.45	1.85			
	185	M	L	10–25	4	0.45	1.87			
	185	M	L	10–25	4	0.46	1.87			
	185	M	L	5–25	5	0.44	1.84			
	185	M	L	5–25	5	0.71	2.7			
	185	M	L	5–30	6	0.65	2.47			25
Filtration Metabolic Efficiency (internal)										
Cardium lamarcki [adult] O –> yeast & sediment	23	M	L	4–20	5			NS	NS	
	23	M	L	4–20	5			NS	NS	
	23	M	L	4–20	5			NS	NS	

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	23	M	L	4–28	7			0.32	0.64	
	23	M	L	4–28	7			NS	NS	
	23	M	L	4–28	7	NS	NS			
Cerastoderma edule [adult] O –> yeast & sediment	23	M	L	4–20	5			0.15	0.81	
	23	M	L	4–20	5			0.25	0.7	
	23	M	L	4–28	7			0.57	0.45	8
	23	M	L	4–28	7			0.76	0.35	
	23	M	L	4–28	7			1.04	0.24	
Ostrea edulis [adult] O –> Phaeodactylum tricornutum P	132	M	L	10–30	6			0.71	0.38	
	132	M	L	10–30	6			0.79	0.34	
	132	M	L	10–30	6			NS	NS	
	132	M	L	10–30	6			NS	NS	
	132	M	L	10–30	6			NS	NS	
Filtration Rate (species interaction)										
Cardium lamarcki [adult] O –> yeast & sediment	23	M	L	4–20	5	0.71	2.78			
	23	M	L	4–20	5	NS	NS			
	23	M	L	4–20	5	NS	NS			
	23	M	L	4–28	7	0.57	2.23			24
	23	M	L	4–28	7	1.09	4.74			20
Cerastoderma edule [adult] O –> yeast & sediment	23	M	L	4–20	5	0.42	1.83			
	23	M	L	4–20	5	0.56	2.23			
	23	M	L	4–20	5	NS	NS			
	23	M	L	4–28	7			0.65	0.42	12
	23	M	L	4–28	7	NS	NS			
Ciona intestinalis [adult] O –> Rhodomonas spp. P	141	M	L	4.3–21.6	5	0.59	2.33			18.1
	141	M	L	5.3–20.7	4	0.65	2.52			
	141	M	L	5–22	5	NS	NS			19.5
	141	M	L	6.3–21.5	5	0.79	3.09			18.1
	141	M	L	6.3–21.6	5	0.64	2.46			
Conopeum reticulum [adult] O –> Cryptomonas spp. P	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4					18

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4	0.35	1.65			
	123	M	L	6–22	4	0.42	1.81			
	123	M	L	6–22	4	0.44	1.86			
	123	M	L	6–22	4	0.55	2.16			
Daphnia magna [adult] O –> Scenedesmus acutus P	119	F	L	10–25	4					20
	119	F	L	5–25	5			0.29	0.67	10
	119	F	L	5–25	5	0.67	2.57			
	119	F	L	5–25	5	0.84	3.31			20
	119	F	L	5–25	5	NS	NS			
Daphnia rosea [adult] O –> Chlamydomonas spp. P	91	M	L	5–25.2	9	0.29	1.52	0.16	0.81	14.1
Electra crustulenta [adult] O –> Rhodomonas spp. P	111	M	L	6–24	6	0.6	2.32			22
Electra pilosa [adult] O –> Cryptomonas spp. P	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4					18
	123	M	L	6–22	4	0.55	2.18			
	123	M	L	6–22	4	0.45	1.89			
	123	M	L	6–22	4	0.26	1.43			
	123	M	L	6–22	4	0.4	1.76			
	123	M	L	6–22	4	0.49	1.99			
Halichondria panicea [adult] O –> Rhodomonas spp. P	151	M	L	6.1–14.9	10	1.54	9.19			
	151	M	L	6.1–15	10	0.72	2.84			
	151	M	L	6–14.9	9	1.04	4.45			
	151	M	L	7–13.9	4	NS	NS			
Hiatella arctica [adult] O –> Phaeodactylum tricornutum P	3	M	L	1.6–24.9	8	0.97	4.16	3.42	0.01	15.4
	3	M	L	3.3–22.4	4					16.3
Mya arenaria [adult] O –> Rhodomonas spp. P	149	M	L	4–22.3	6	0.32	1.58			18

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	149	M	L	5.6–22	5	0.35	1.63			
Mytilus californianus [adult] O –> colloidal graphite	145	M	L	5–20	4	NS	NS			
Mytilus edulis [adult] O –> Phaeodactylum tricornutum P	186	M	L	5–25	5			NS	NS	10
Mytilus edulis [adult] O –> Rhodomonas spp. P	89	M	L	2.7–15	6	0.41	1.81			
	89	M	L	4.9–14.8	4	0.29	1.51			
	89	M	L	5.6–21.4	7	0.33	1.59			
	94	M	L	4.8–19.6	7	0.3	1.54			
	94	M	L	8.6–19.4	6	0.33	1.6			17.3
Nereis diversicolor [adult] C –> phytoplankton P	152	M	L	11–24	6			NS	NS	
Nereis diversicolor [adult] C –> Rhodomonas spp. P	152	M	L	5.1–25	6	0.36	1.67			16
	152	M	L	7.9–26.7	4					14.9
	152	M	L	8.1–26.3	11	0.39	1.7			23.4
	152	M	L	8.4–21.6	4					18.9
Ostrea edulis [adult] O –> Phaeodactylum tricornutum P	132	M	L	10–30	6			NS	NS	
	132	M	L	5–30	7	1.15	NS			
	132	M	L	5–30	7	1.56	9.25			20
	132	M	L	5–30	7	2.42	31.24	NS	NS	
	132	M	L	5–30	7	NS	NS	NS	NS	
Paraphysomonas imperforata C –> Phaeodactylum tricornutum P	26	M	L	14–26	4	NS	NS			
Rutilus penicillus [adult] O –> Rhodomonas spp. P	150	M	L	13.7–21.8	6	0.18	1.28			
	150	M	L	6.2–21.6	8	0.31	1.56			
Flee Distance (individual)										
Homo sapiens [adult] O –> Holbrookia propinqua [adult] C	35	T	F	26.6–49.3	12	0.6	2.03			
	35	T	F	29.3–49.6	7	NS	NS			
Homo sapiens [adult] O –> Sceloporus mucronatus [adult] O	160	T	F	26.1–34.1	8	1.58	7.48			
Homo sapiens [adult] O –> Urosaurus bicarinatus [adult] C	160	T	F	35.2–40.6	4			NS	NS	
Food Energy Assimilation Efficiency (internal)										
Acroneuria californica [juvenile] O –> Hydropsyche spp. [juvenile] O	75	F	L	10–26	5			0.58	0.45	
	75	F	L	8–20	4			0.58	0.44	
Acroneuria californica [juvenile] O –> Simulium spp. [juvenile] O	75	F	L	10–24	7			NS	NS	
	75	F	L	11–23	4			NS	NS	
	75	F	L	13–27	4					17

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Food Mass Conversion Efficiency (internal)										
Cherax quadricarinatus [juvenile] O –> crayfish ration	121	F	L	16–32	9			0.22	0.75	20
Dicentrarchus labrax [juvenile] C –> commercial extruded dry pellet	138	M	L	13.4–28.8	6	0.39	1.71			21.9
Paraphysomonas imperforata C –> Halomonas marina D	154	M	L	0–20	5	0.23	1.4			15
Foraging Behaviour Probability (species interaction)										
Calidris mauri [adult] C –> mudflat invertebrate	131	T	F	25–35	8			NS	NS	
	131	T	F	25–35	8	NS	NS			
Foraging Body Undulation Rate (individual)										
Nereis diversicolor [adult] C –> Rhodomonas spp. P	152	M	L	6.1–16.9	7	0.48	1.98			
	152	M	L	7.6–27.8	8	0.41	1.75			
	152	M	L	7.9–26.7	4	0.42	1.77			
Foraging Gill Beat Rate (individual)										
Ciona intestinalis [adult] O –> Rhodomonas spp. P	137	M	L	7.4–20.1	4	NS	NS			
Foraging Rate (species interaction)										
Bembidion lampros [adult] C	31	T	L	10–30	4					20
	31	T	L	5–30	5	NS	NS			
	31	T	L	5–30	5	NS	NS			
Cicindela hybrida [adult] C	42	T	F	22.4–43.5	8	0.68	2.35			37.4
Nereis diversicolor [adult] C –> Rhodomonas spp. P	152	M	L	5.5–28	11	0.45	1.85			
Pterostichus cupreus [adult] C	31	T	L	5–30	5					15
	31	T	L	5–30	5			NS	NS	
	31	T	L	5–30	5	NS	NS			
	31	T	L	5–30	5	NS	NS			
Foraging Submersion Rate (individual)										
Notonecta glauca [adult] C	34	F	L	5–25	5	1.09	4.65			
	34	F	L	5–25	5	1.45	7.72			
	34	F	L	5–25	5	1.69	10.75			
	34	F	L	5–25	5	1.93	14.91			
Foraging Velocity (individual)										
Acromyrmex versicolor [adult] H	83	T	F	17.2–32.4	8	0.53	2			30.3
Aphaenogaster senilis [adult] H	102	T	F	6–40	14	0.7	2.5			
Cicindela hybrida [adult] C	42	T	F	17.5–42.6	15	0.27	1.42	NS	NS	33

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Dorymyrmex goetschi [adult] O	172	T	F	18.9–37.4	5	0.2	1.29			
Formica rufa [adult] C	79	T	F	9.1–20.8	5	0.52	2.05			
	79	T	F	9.8–17.5	6	0.6	2.32			
Gymnocephalus cernuus [adult] C	18	F	L	4–20	5	0.18	1.3			
Kinixys spekii [adult] H	67	T	F	21.5–38.5	8			0.97	0.29	
Leptogenys intermedia [adult] C	44	T	L	20–35	4	0.54	1.99			
Leptogenys schwabi [adult] C	44	T	L	20–35	4	0.41	1.7			
Linepithema humile [adult] C	33	T	F	5.9–35.6	10	0.7	2.54			
	33	T	F	8.4–35.3	7	0.4	1.71			
	158	T	F	25.5–33.8	6	0.46	1.8			
Liometopum apiculatum [adult] O	157	T	F	9.7–38.3	10	0.61	2.23			
Messor pergandei [adult] H	83	T	F	21.5–36.3	5	0.72	2.51			34.1
	108	T	F	21.4–43.2	11	0.4	1.71			40
	153	T	F	17–37.4	6	0.44	1.77			34.5
Ocymyrmex barbiger [adult] C	115	T	F	28.6–61.2	12	0.44	1.65			
Perca fluviatilis [adult] O	18	F	L	4–20	5	0.72	2.79			
Pogonomyrmex barbatus [adult] H	128	T	F	25–51.7	10	0.32	1.48			
Pogonomyrmex desertorum [adult] H	128	T	F	27.2–48.4	8	0.42	1.65			45.9
Pogonomyrmex maricopa [adult] H	182	T	F	26.1–45.8	10	0.69	2.32			43.8
Pogonomyrmex occidentalis [adult] H	128	T	F	34.1–50	15	NS	NS			
Pogonomyrmex rugosus [adult] H	182	T	F	24.5–44	11	0.55	1.99			41.1
Rutilus rutilus [adult] O –> Chaoborus obscuripes [juvenile] C	140	F	L	12–21	4	NS	NS			
Solenopsis invicta [adult] O	148	T	F	10.5–32.3	10	0.54	2.05			
Tapinoma sessile [adult] O	158	T	F	20.4–36.9	10	0.49	1.87			
Grazing Rate (species interaction)										
Glossosoma spp. [juvenile] H –> periphyton P	93	F	L	3–21	7			0.57	0.45	9
Gut Clearance Rate (internal)										
Aurelia aurita [juvenile] C –> Clupea harengus [juvenile] H	74	M	L	5–22	4	0.66	2.55			
Centropages hamatus [adult] O –> Ditylum brightwellii P	92	M	L	1–15	4	0.92	3.84			
Conopeum reticulum [adult] O –> Cryptomonas spp. P	123	M	L	6–22	4	0.36	1.67			
Electra pilosa [adult] O –> Cryptomonas spp. P	123	M	L	6–22	4	0.5	2.03			
Gadus morhua [juvenile] C –> dead Pandalus montagui [adult]	174	M	L	2–19	5	0.73	2.92			15

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	**Cit**	**Hab**	**L/F**	**Temp**	**N**	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	174	M	L	2–19	5	0.75	2.99			15
Hexagenia limbata [juvenile] H –> sediment 'a'	192	F	L	5–25	5	0.43	1.86			20
	192	F	L	5–25	5	0.44	1.88			20
Pleuronectes platessa [adult] C –> Arenicola marina [adult] O	46	M	L	1–20	5	0.48	1.99			
	46	M	L	1–20	5	1.15	5.25			
Pleuronectes platessa [juvenile] C –> fish-paste	85	M	L	5–21	5	0.49	2			
Uta stansburiana [adult] C –> Acheta sp. A [adult] O	178	T	L	22–32	5	NS	NS			
	178	T	L	22–32	5	NS	NS			
Gut Loading Rate (internal)										
Hexagenia limbata [juvenile] H –> sediment 'a'	192	F	L	5–25	5	0.51	2.09			20
Handling Rate (species interaction)										
Gymnocephalus cernuus [adult] C –> Chaoborus obscuripes [juvenile] C	18	F	L	4–20	5	0.28	1.49			
Perca fluviatilis [adult] O –> Chaoborus obscuripes [juvenile] C	18	F	L	4–20	5	0.83	3.24			
Host-Per-Parasitoid Parasitization Rate (species interaction)										
Anisopteromalus calandrae [adult] C –> Rhyzopertha dominica [juvenile] H	122	T	L	20–35	4					30
	122	T	L	20–35	4					35
	122	T	L	20–35	4					35
	122	T	L	20–35	4	NS	NS			
	122	T	L	20–35	4	NS	NS			
Anisopteromalus calandrae [adult] C –> Sitophilus zea-mais [juvenile] H	161	T	L	20.2–35.3	4	NS	NS			
Cardiochiles philippinensis [adult] C –> Cnaphalocrocis medinalis [juvenile] H	156	T	L	25–35	5			0.55	0.5	
	156	T	L	25–35	5			0.74	0.39	
	156	T	L	25–35	5			0.84	0.35	28
	156	T	L	25–35	5			1.08	0.26	28
	156	T	L	25–35	5			NS	NS	
	156	T	L	25–35	5			NS	NS	28
Cephalonomia waterstoni [adult] C –> Cryptolestes ferrugineus [juvenile] H	53	T	L	20–38	5					25
	53	T	L	20–38	5					30
	53	T	L	20–38	5					30
	53	T	L	20–38	5			NS	NS	25
	53	T	L	20–38	5	NS	NS			35
Praon exsoletum [adult] C –> Therioaphis trifolii [adult] H	124	T	L	10–23.9	5					23.9

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	124	T	L	10–23.9	5	NS	NS			
	124	T	L	10–26.7	4					12.8
	124	T	L	10–26.7	4					23.9
	124	T	L	10–26.7	6					15.6
	124	T	L	10–26.7	6	NS	NS			21.1
	124	T	L	10–26.7	6	NS	NS			23.9
	124	T	L	10–26.7	6	NS	NS	NS	NS	23.9
	124	T	L	10–26.7	7	0.72	2.7			23.9
	124	T	L	10–26.7	7	NS	NS			23.9
	124	T	L	11.4–25.8	4					21.1
	124	T	L	11.4–25.8	4	NS	NS			
Theocolax elegans [adult] C –> Rhyzopertha dominica [juvenile] H	52	T	L	20–32.5	4					30
	52	T	L	20–32.5	4					30
In Vitro Gill Beat Rate (individual)										
Dreissena polymorpha [adult] O	103	F	L	8–22	4	0.5	2.01			
	103	F	L	8–22	4	0.5	2			
In Vitro Gill Particle Transport Velocity (individual)										
Mytilus edulis [adult] O –> yeast D	88	M	L	5–20	4	0.36	1.67			
	88	M	L	5–20	4	0.45	1.91			
	88	M	L	5–20	4	0.47	1.96			
	88	M	L	5–20	4	0.49	2.01			
Mytilus sp. A [adult] O	64	M	L	0–35	10	0.61	2.34			32.5
In Vitro Heart Beat Rate (internal)										
Oceanites oceanicus [egg] S	187	T	L	10.1–40.4	15	0.86	3.05			
Oceanodroma leucorhoa [egg] S	187	T	L	12–41	14	1.15	4.4			
In Vitro Muscle Isometric Tension (internal)										
Myoxocephalus scorpius [adult] C	11	M	L	0–20	5			NS	NS	15
	11	M	L	0–20	5	0.3	1.56			15
In Vitro Muscle Optimal Phase (internal)										
Manduca sexta [adult] H	166	T	L	20.2–40.3	5			NS	NS	
In Vitro Muscle Optimal Rate (internal)										
Manduca sexta [adult] H	166	T	L	20–39.9	5	0.32	1.5			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
In Vitro Muscle Optimal Strain (internal)										
Manduca sexta [adult] H	166	T	L	19.9–39.9	5	0.13	1.17			
In Vitro Muscle Power Output (internal)										
Manduca sexta [adult] H	166	T	L	20–40	5	0.6	2.14			
In Vitro Muscle Shortening Velocity (internal)										
Myoxocephalus scorpius [adult] C	11	M	L	0–20	5	0.23	1.39			
	11	M	L	0–20	5	0.41	1.81			
In Vitro Muscle Work Per Cycle (internal)										
Manduca sexta [adult] H	166	T	L	20–40	5	0.28	1.42			
Individual Length Growth Rate (individual)										
Moina macrocopa [adult] O –> Chlorella sorokiniana P	16	F	L	15–30	5	0.99	3.7			
Moina macrocopa [juvenile] O –> Chlorella sorokiniana P	16	F	L	15–30	5	0.86	3.14			
Individual Mass Growth Rate (individual)										
Caulerpa serrulata [adult] P –> light	107	M	L	5–40	8	0.6	2.27			30
Cherax quadricarinatus [juvenile] O –> crayfish ration	121	F	L	16–32	9	2.57	30.3			28
Dicentrarchus labrax [juvenile] C –> commercial extruded dry pellet	138	M	L	13.4–28.8	6	0.94	3.58			24.9
Intraspecific Confrontation Probability Density (species interaction)										
Bembidion lampros [adult] C	31	T	L	5–30	5					20
	31	T	L	5–30	5					20
Pterostichus cupreus [adult] C	31	T	L	5–30	5	0.61	2.31			
	31	T	L	5–30	5	0.61	2.34			
	31	T	L	5–30	5	NS	NS			
	31	T	L	5–30	5	NS	NS			
Line Encounter Rate (species interaction)										
Pogonomyrmex occidentalis [adult] H	36	T	F	23.5–52.2	5					41.6
	36	T	F	23.7–57.3	11	1.16	4.13	NS	NS	
	36	T	F	24.3–51.4	9	1.35	5.15			47.1
	36	T	F	25.7–55.8	7	0.83	2.74			46.3
	36	T	F	26.5–51.4	9	1.02	3.34			
	36	T	F	26.6–57.9	13	1.52	6.41	1.95	0.11	42.9
	36	T	F	26.9–58.3	10	1.27	4.5	NS	NS	51.8
	36	T	F	27.3–51.1	11	0.59	2.01			48.3

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	**Cit**	**Hab**	**L/F**	**Temp**	**N**	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	36	T	F	27.7–57.1	11	1.12	3.75	0.87	0.38	42.6
	36	T	F	27.9–57.9	8	1.88	9.86	NS	NS	42.1
	36	T	F	28.2–50.5	9	NS	NS	NS	NS	42.7
	36	T	F	28.6–56.7	9	1.13	3.71	NS	NS	
	36	T	F	28.9–58.1	11	1.52	6.31	2.37	0.07	43.6
	36	T	F	29.5–55.3	10	1.21	4.19	NS	NS	47.2
	36	T	F	30.7–59	11	1.1	3.71	1.38	0.22	47.9
	36	T	F	32.3–53.6	6	NS	NS			44.6
	36	T	F	32.9–51.4	5			NS	NS	39
	36	T	F	32.9–52.8	6	NS	NS			49.7
	36	T	F	33.5–53.2	6	NS	NS			45
	36	T	F	36.1–55	7	NS	NS			
	36	T	F	37–56.4	9	NS	NS			
	36	T	F	45.7–56.5	4					49.8
Log-Linear Gut Clearance Rate (internal)										
Temora longicornis [adult] O –> Thalassiosira weissflogii [adult] P	37	M	L	1–17	10	0.88	3.65			13
Mortality Rate (population)										
Aphis gossypii [adult] H –> Cucumis sativus P	191	T	L	10–30	5	0.54	2.08			
	191	T	L	10–30	5	NS	NS			
Aphis gossypii [juvenile] H –> Cucumis sativus P	191	T	L	10–30	5	NS	NS			
Euplectrus ronnai [juvenile] C –> Pseudaletia sequax [juvenile] H	189	T	L	15–29	5	NS	NS			
Moina macrocopa [adult] O –> Chlorella sorokiniana P	16	F	L	15–30	5	0.43	1.78			
Planococcus citri [adult] H –> Solenostemon scutellarioides P	61	T	L	18–32	7	0.32	1.52			
	61	T	L	18–32	7	0.47	1.86			30
	61	T	L	18–32	7	NS	NS	0.32	0.66	25
Procambarus clarkii [adult] O –> uncooked mixed vegetables	30	F	L	15–30	6	0.68	2.45			
Procambarus clarkii [juvenile] O –> uncooked mixed vegetables	30	F	L	15–30	6	0.66	2.4			
Telenomus chrysopae [juvenile] C –> Chrysoperla rufilabris [egg] S	155	T	L	15.6–26.7	5	NS	NS			
Telenomus isis [adult] C –> Busseola fusca [egg] S	25	T	L	18–32	6	0.6	2.19			
	25	T	L	18–32	6	0.8	2.87			
Telenomus isis [adult] C –> Sesamia calamistis [egg] S	25	T	L	18–32	6	0.94	3.44			
	25	T	L	18–32	6	1.03	3.86			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Telenomus isis [adult] C –> Sesamia nonagrioides [egg] S	25	T	L	18–32	6	0.54	2.03			30
	25	T	L	18–32	6	1.12	4.33			
Telenomus isis [juvenile] C –> Busseola fusca [egg] S	25	T	L	18–32	6	0.55	2.06			30
	25	T	L	18–32	6	0.74	2.65			
Telenomus isis [juvenile] C –> Sesamia calamistis [egg] S	25	T	L	18–32	6	0.54	2.04			
	25	T	L	18–32	6	NS	NS			
Telenomus isis [juvenile] C –> Sesamia nonagrioides [egg] S	25	T	L	18–32	6	0.47	1.87			
	25	T	L	18–32	6	0.57	2.12			
Tetraneura nigri abdominalis [adult] H –> Oryza sativa P	98	T	L	10–30	5	0.56	2.13			
	98	T	L	10–35	6	0.24	1.38			
Theocolax elegans [adult] C	84	T	L	20–35	6	0.58	2.12			
	84	T	L	20–35	6	0.86	3.04			
Nest Provisioning Rate (species interaction)										
Buteo jamaicensis [adult] C –> Serpentes spp. [adult] C	168	T	F	15.3–30.2	12			0.43	0.57	
Oxygen Mass Scope For Activity (internal)										
Oncorhynchus mykiss [adult] C	39	F	L	5–25	5					15
	39	F	L	5–25	5					20
Photosynthetic Oxygen Production Rate (internal)										
Caulerpa serrulata [adult] P –> light	107	M	L	5–40	8	0.66	2.48			30
Lithophyllum margaritae P –> light	164	M	L	10–30	5	NS	NS			25
POC Photosynthetic Oxygen Production Rate (internal)										
Phaeodactylum tricornutum P –> light	69	M	L	0–30	7	0.38	1.71			25
Prorocentrum minimum P –> light	69	M	L	0–30	7	0.51	2.07			25
Prymnesium patelliferum O –> light	69	M	L	0–30	7	0.4	1.75			25
Point Encounter Density Rate (species interaction)										
Phytoseiulus persimilis [adult] C	48	T	L	15–30	4					25
Tetranychus urticae [adult] H	48	T	L	15–30	4	NS	NS			
Point Encounter Number Rate (species interaction)										
Homarus americanus [adult] C	147	M	L	11–28.5	9	0.76	2.81			
Salmo salar [juvenile] C	142	F	L	6–21	6	1.2	5.36			
	142	F	L	6–27	8	0.78	2.95			
Population Catchability (species interaction)										

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	**Cit**	**Hab**	**L/F**	**Temp**	**N**	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Homarus americanus [adult] C	120	M	F	2.8–11.5	6	2.28	29.18			
Population Density (population)										
Acartia sinjiensis [adult] O –> microalgae P	125	M	L	10–38	8	1.68	9.45			30
Acarus siro [adult] H –> wheat germs, oat flakes and baker's yeast	6	F	L	5–35	12	1.71	10.5	2.19	0.06	27.5
Aleuroglyphus ovatus [adult] H –> wheat germs, oat flakes and baker's yeast	6	T	L	5–35	12	2.23	21.15	NS	NS	27.5
Tyrophagus putrescentiae [adult] H –> wheat germs, oat flakes and baker's yeast	6	T	L	10–35	11	1.33	6.26			20
Population Foraging Probability (species interaction)										
Brachycentrus americanus [juvenile] H –> dead Artemia spp. [adult]	57	F	F	8.6–30	5	NS	NS			24.6
	57	F	F	8.8–30.9	6					13.1
	57	F	F	15.4–26.3	7			0.24	0.73	
	57	F	F	15.4–26.3	7			0.26	0.7	
	57	F	F	15.4–26.3	7			0.39	0.59	15.4
	57	F	F	4–16	4	NS	NS			
	57	F	F	4–16	4	NS	NS			
Hyles lineata [juvenile] H –> desert plant P	27	T	F	14.8–36.1	6					27.5
Manduca sexta [juvenile] H –> Datura inoxia P	27	T	F	18.9–35.8	6			0.36	0.63	22.6
Population Growth Rate (population)										
Acarus siro [adult] H –> wheat germs, oat flakes and baker's yeast	6	T	L	5–35	12	1.93	13.86	0.76	0.38	26.3
Aleuroglyphus ovatus [adult] H –> wheat germs, oat flakes and baker's yeast	6	T	L	5–35	12	1.74	10.73	NS	NS	26.3
Aphis gossypii [adult] H –> Cucumis sativus P	191	T	L	10–30	5	0.91	3.47			25
Chlorella vulgaris P –> light + mineral medium	38	F	L	10–35	6	0.39	1.69			30
Coelastrum microporum P –> light	20	F	L	15–35	5	0.5	1.92			
Cosmarium subprotumidum P –> light	20	F	L	15–35	5	NS	NS			
Escherichia coli O –> luria broth	24	T	L	10–45	11	0.45	1.81	NS	NS	37
Fragilaria crotonensis P –> light + mineral medium	38	F	L	10–35	6	0.47	1.9			25
Lemna minor P –> aqueous growth medium	101	F	L	5–35	12	1.09	4.49	1.35	0.18	27
Moerisia lyonsi [adult] C –> Acartia tonsa O	114	M	L	10–29	5	1.56	8.24			
Paraphysomonas imperforata C –> Halomonas marina D	154	M	L	0–20	5	1.04	4.58			15
Paraphysomonas imperforata C –> Phaeodactylum tricornutum P	26	M	L	14–26	4	0.65	2.41			
Planococcus citri [adult] H –> Solenostemon scutellarioides P	61	T	L	18–32	7	1.18	4.84	NS	NS	25
Salmonella enterica C –> tetrathionate broth	24	T	L	10–43	10	0.56	2.09			36
Selenastrum minutum P –> light	20	F	L	15–35	5	0.34	1.56			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Staurastrum pingue P –> light + mineral medium	38	F	L	10–35	6	0.56	2.15			25
Synechocystis minima P –> light + mineral medium	38	F	L	10–35	6	0.36	1.61			
Telenomus isis [adult] C –> Busseola fusca [egg] S	25	T	L	18–32	6	0.74	2.64			30
	25	T	L	18–32	6	0.95	3.53			27
Telenomus isis [adult] C –> Sesamia calamistis [egg] S	25	T	L	18–32	6	0.75	2.67			30
	25	T	L	18–32	6	0.98	3.67			27
Telenomus isis [adult] C –> Sesamia nonagrioides [egg] S	25	T	L	18–32	6	0.87	3.15			27
	25	T	L	18–32	6	NS	NS			27
Tetraneura nigri abdominalis [adult] H –> Oryza sativa P	98	T	L	10–30	5	0.87	3.21			
Tyrophagus putrescentiae [adult] H –> wheat germs, oat flakes and baker’s yeast	6	T	L	10–35	11	1.37	6.63			25.6
Urotricha farcta H –> Cryptomonas spp. P	183	F	L	9–24	6	0.6	2.28			
Population Voluntary Activity Probability (individual)										
Crangonyx richmondensis [adult] O	180	F	L	3.9–22.1	8	0.97	4.02			20.2
Hyallela azteca [adult] O	180	F	L	8–23.3	6	1.34	6.53			20.4
Population Voluntary Movement Probability (individual)										
Crangonyx richmondensis [adult] O	180	F	L	5–20	5					12.5
Hyallela azteca [adult] O	180	F	L	8.9–20	4			NS	NS	
Pomacea paludosa [adult] H –> lettuce, spinach, bladderwort P	165	F	L	14.5–21.3	6	NS	NS			
	165	F	L	14.5–24	6	1.81	11.72			
	165	F	L	17–22	5	2.06	16.33			
Radial Growth Rate (population)										
Beauveria bassiana [adult] C –> agar medium	49	T	L	8–32	8	0.91	NS			20
	49	T	L	8–35	9	0.55	2.13	NS	NS	25
	49	T	L	8–35	9	0.63	2.42	NS		20
	49	T	L	8–35	9	0.65	2.46			28
	49	T	L	8–35	9	0.8	3.03			28
	49	T	L	8–35	9	0.83	3.1			28
	49	T	L	8–35	9	0.83	3.15	NS	NS	25
	49	T	L	8–35	9	0.86	3.21	NS	NS	25
	49	T	L	8–35	9	0.88	3.37	NS	NS	25
	49	T	L	8–35	9	0.94	3.67	NS	NS	25
	49	T	L	8–35	9	1	3.97			28

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	49	T	L	8–35	9	1.12	4.79			20
	49	T	L	8–35	9	NS	NS	NS	NS	25
	49	T	L	8–37	10	0.49	1.96	4.08	0.01	28
	49	T	L	8–37	10	0.51	2.04	3.85	0.01	25
	49	T	L	8–37	10	0.56	2.16	3.32	0.02	25
	49	T	L	8–37	10	0.57	2.17	NS	NS	28
	49	T	L	8–37	10	0.58	2.2	3.74	0.01	28
	49	T	L	8–37	10	0.61	2.29	NS	NS	28
	49	T	L	8–37	10	0.62	2.35	NS	NS	25
	49	T	L	8–37	10	0.64	2.42	NS	NS	25
	49	T	L	8–37	10	0.65	2.43			25
	49	T	L	8–37	10	0.66	2.49	3.47	0.01	25
	49	T	L	8–37	10	0.66	2.47	5.14	0	28
	49	T	L	8–37	10	0.66	2.46			30
	49	T	L	8–37	10	0.68	2.49	NS	NS	28
	49	T	L	8–37	10	0.7	2.6	NS	NS	28
	49	T	L	8–37	10	0.73	2.73	2.83	0.03	25
	49	T	L	8–37	10	0.73	2.73	NS	NS	25
	49	T	L	8–37	10	0.75	2.82	NS	NS	25
	49	T	L	8–37	10	0.76	2.82	NS	NS	28
	49	T	L	8–37	10	0.77	2.9	2.89	0.03	25
	49	T	L	8–37	10	0.77	2.88	NS	NS	25
	49	T	L	8–37	10	0.78	2.95	NS	NS	25
	49	T	L	8–37	10	0.79	2.99	3.97	0.01	25
	49	T	L	8–37	10	0.8	3.03	NS	NS	25
	49	T	L	8–37	10	0.83	3.1	NS	NS	25
	49	T	L	8–37	10	0.83	3.12	NS	NS	25
	49	T	L	8–37	10	0.83	3.05	NS	NS	28
	49	T	L	8–37	10	0.85	3.2	2.15	0.07	25
	49	T	L	8–37	10	0.85	3.22	NS	NS	25
	49	T	L	8–37	10	0.85	3.2	NS	NS	28
	49	T	L	8–37	10	0.86	3.29	NS	NS	28

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	**Cit**	**Hab**	**L/F**	**Temp**	**N**	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	49	T	L	8–37	10	0.88	3.37	NS	NS	25
	49	T	L	8–37	10	0.89	3.433.	NS	NS	25
	49	T	L	8–37	10	0.91	2.4	4.28	0	25
	49	T	L	8–37	10	0.93	3.56	NS	NS	25
	49	T	L	8–37	10	0.93	3.55	NS	NS	28
	49	T	L	8–37	10	0.95	3.71	NS	NS	25
	49	T	L	8–37	10	0.96	3.78	NS	NS	28
	49	T	L	8–37	10	0.98	3.86	NS	NS	25
	49	T	L	8–37	10	1	3.93	0.83	0.35	25
	49	T	L	8–37	10	1	3.95	NS	NS	25
	49	T	L	8–37	10	1.01	4.03	NS	NS	25
	49	T	L	8–37	10	1.03	4.13	NS	NS	20
	49	T	L	8–37	10	1.03	4.1	NS	NS	25
	49	T	L	8–37	10	1.04	4.19	NS	NS	25
	49	T	L	8–37	10	1.05	4.19	NS	NS	25
	49	T	L	8–37	10	1.05	4.21	NS	NS	28
	49	T	L	8–37	10	1.07	4.34	NS	NS	25
	49	T	L	8–37	10	1.11	4.62	0.84	0.35	25
	49	T	L	8–37	10	1.31	6.1	NS	NS	25
	49	T	L	8–37	10	1.36	6.47	NS	NS	25
	49	T	L	8–37	10	1.54	8.26	NS	NS	25
	49	T	L	8–37	10	NS	NS	NS	NS	25
Metarhizium anisopliae [adult] C –> agar medium	136	T	L	11–37	9			NS	NS	25
	136	T	L	11–37	9			NS	NS	25
	136	T	L	11–37	9			NS	NS	25
	136	T	L	11–37	9	NS	NS			29
	136	T	L	8–35	9	0.69	NS	1.94	0.08	25
	136	T	L	8–35	9	1.08	4.44	NS	NS	25
	136	T	L	8–35	9	1.24	5.51	NS	NS	25
	136	T	L	8–35	9	1.62	9.26			25
	136	T	L	8–35	9	NS	NS	NS	NS	25
	136	T	L	8–37	10	0.76	2.82	NS	NS	25

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\ R}$	E_F	$Q_{10\ F}$	T_{opt}
	136	T	L	8–37	10	0.82	3.02	1.78	0.11	28
	136	T	L	8–37	10	0.88	3.25	2	0.08	28
	136	T	L	8–37	10	0.89	NS	1.59	0.13	25
	136	T	L	8–37	10	0.89	3.33	NS	NS	28
	136	T	L	8–37	10	1	3.92	2.47	0.05	26.5
	136	T	L	8–37	10	1.01	3.94	0.71	0.41	25
	136	T	L	8–37	10	1.02	4.01	NS	NS	28
	136	T	L	8–37	10	1.03	4.1	NS	NS	28
	136	T	L	8–37	10	1.07	4.34	1.89	0.09	25
	136	T	L	8–37	10	1.16	NS			30
	136	T	L	8–37	10	NS	NS	NS	NS	25
	136	T	L	8–37	10	NS	NS	NS	NS	25
Metarhizium flavoviride [adult] C –> agar medium	136	T	L	11–37	9	0.66	NS			30
	136	T	L	11–37	9	0.72	NS			30
	136	T	L	11–37	9	0.79	NS			30
	136	T	L	11–37	9	NS	NS	NS	NS	28
	136	T	L	11–37	9	NS	NS	NS	NS	28
	136	T	L	11–37	9	NS	NS	NS	NS	28
	136	T	L	8–37	10	0.78	2.92	NS	NS	25
	136	T	L	8–37	10	0.78	2.93	NS	NS	28
	136	T	L	8–37	10	1.08	4.3	NS	NS	28
	136	T	L	8–37	10	1.28	NS			30
	136	T	L	8–37	10	1.31	5.88	NS	NS	28
	136	T	L	8–37	10	1.38	6.55	NS	NS	28
	136	T	L	8–37	10	1.43	7.02	NS	NS	26.5
	136	T	L	8–37	10	1.75	11.14	NS	NS	25
Paecilomyces fumosoroseus C –> agar medium	176	T	L	8–30	7	0.83	3.14			25
	176	T	L	8–30	7	0.88	3.36			25
	176	T	L	8–32	8	0.54	NS			25
	176	T	L	8–32	8	0.56	NS			25
	176	T	L	8–32	8	0.63	2.41	NS	NS	20
	176	T	L	8–32	8	0.69	2.66	NS	NS	20

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	176	T	L	8–32	8	0.74	NS			25
	176	T	L	8–32	8	0.78	2.99	NS	NS	20
	176	T	L	8–32	8	0.93	3.66	NS	NS	20
	176	T	L	8–35	9	0.55	NS			28
	176	T	L	8–35	9	0.61	2.29			30
	176	T	L	8–35	9	0.64	2.4	NS	NS	25
	176	T	L	8–35	9	0.72	NS			28
	176	T	L	8–35	9	0.76	2.89	NS	NS	20
	176	T	L	8–35	9	0.79	NS			28
	176	T	L	8–35	9	0.8	NS			28
	176	T	L	8–35	9	0.8	NS			28
	176	T	L	8–35	9	0.83	NS			28
	176	T	L	8–35	9	0.85	NS			28
	176	T	L	8–35	9	0.86	NS			28
	176	T	L	8–35	9	0.86	NS			28
	176	T	L	8–35	9	0.86	3.27	NS	NS	25
	176	T	L	8–35	9	0.9	NS			28
	176	T	L	8–35	9	0.9	NS			28
	176	T	L	8–35	9	0.91	NS			28
	176	T	L	8–35	9	0.91	3.49	NS	NS	25
	176	T	L	8–35	9	0.92	3.56	NS	NS	25
	176	T	L	8–35	9	0.95	3.64	NS	NS	25
	176	T	L	8–35	9	0.96	3.74	NS	NS	25
	176	T	L	8–35	9	0.96	3.76	NS	NS	25
	176	T	L	8–35	9	0.97	3.79	NS	NS	25
	176	T	L	8–35	9	0.98	3.86	NS	NS	25
	176	T	L	8–35	9	1.03	4.13	NS	NS	25
	176	T	L	8–35	9	1.04	4.21	1.97	0.08	25
	176	T	L	8–35	9	1.04	4.16	NS	NS	25
	176	T	L	8–35	9	1.05	4.23	NS	NS	25
	176	T	L	8–35	9	1.1	NS	NS		28
Rattle Rate (individual)										

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Homo sapiens [adult] O –> Crotalus viridis viridis [adult] C	29	T	L	8–36	7	0.42	1.75			
Refuge Distance (species interaction)										
Homo sapiens [adult] O –> Holbrookia propinqua [adult] C	35	T	F	26.6–49.3	12	NS	NS			
	35	T	F	29.3–49.6	7	NS	NS			
Resource Habitat Encounter Density Rate (species interaction)										
Bembidion lampros [adult] C	31	T	L	9–30	4		NS			20
Pterostichus cupreus [adult] C	31	T	L	5–30	5	0.47	1.91			
Resource Reaction Distance (species interaction)										
Homo sapiens [adult] O –> Holbrookia propinqua [adult] C	35	T	F	26–42.5	13	NS	1.68			
	35	T	F	27.9–41.6	10	0.61	2.11			
Homo sapiens [adult] O –> Norops lineatopus [adult] O	144	T	F	24.4–31.1	6			NS	NS	
Homo sapiens [adult] O –> Sceloporus anahuacus [adult] O	160	T	F	23.1–32.8	4			NS	NS	
Homo sapiens [adult] O –> Sceloporus gadoviae [adult] O	160	T	F	27.6–36.9	4			1.2	0.23	
Homo sapiens [adult] O –> Sceloporus mucronatus [adult] O	160	T	F	26.1–34.1	8	NS	NS			
Homo sapiens [adult] O –> Scincella lateralis [adult] C	159	T	F	23.5–33.8	8			0.38	0.62	
Homo sapiens [adult] O –> Urosaurus bicarinatus [adult] C	160	T	F	35.2–40.6	4	NS	NS			
Resource Size Capture Intent Acceptance Probability (species interaction)										
Formica schaufussi [adult] C –> dead Nauphoeta cinerea [adult]	173	T	F	16.5–33.6	7	0.89	3.18			
Respiration Rate (internal)										
Cherax quadricarinatus [juvenile] O –> crayfish ration	121	F	L	16–32	9	3.05	57.99			28
Lithophyllum margaritae P –> light	164	M	L	10–30	5	0.57	2.15			
Sediment Mass Processing Rate (species interaction)										
Pectinaria gouldii [adult] O –> fine sediment	62	M	L	13–19	5	1.27	5.81			
	62	M	L	13–19	5	2.84	51.7			
	62	M	L	13–19	5	NS	NS			
Square Root-Linear Gut Clearance Rate (internal)										
Pleuronectes platessa [juvenile] C –> fish-paste	86	M	L	5–15.5	4	0.55	2.2			
Strike Acceleration (individual)										
Pituophis catenifer affinis [adult] C –> Mus musculus [adult] O	65	T	L	18–33	4					27
	65	T	L	18–33	4					27
Strike Completion Rate (individual)										
Pituophis catenifer affinis [adult] C –> Mus musculus [adult] O	65	T	L	18–33	4					27

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	**Cit**	**Hab**	**L/F**	**Temp**	**N**	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
Strike Distance (individual)										
Pituophis catenifer affinis [adult] C –> Mus musculus [adult] O	65	T	L	18–33	4			NS	NS	
Strike Velocity (individual)										
Pituophis catenifer affinis [adult] C –> Mus musculus [adult] O	65	T	L	18–33	4					22
	65	T	L	18–33	4					27
	65	T	L	18–33	4					27
	65	T	L	18–33	4					27
	65	T	L	18–33	4					27
	65	T	L	18–33	4					27
	65	T	L	18–33	4					27
	65	T	L	18–33	4			NS	NS	
	65	T	L	18–33	4	NS	NS			
Subjugation-Consumption Body Contraction Rate (individual)										
Aurelia aurita [juvenile] C –> Clupea harengus [juvenile] H	74	M	L	5–22	4	NS	NS			
Subjugation-through-Consumption Rate (species interaction)										
Cicindela hybrida [adult] C –> cursorial insect	42	T	F	25.3–40.3	6			NS	NS	
Notonecta hoffmani [adult] C –> Culex pipiens [juvenile] O	129	F	L	10.8–25	4	0.72	2.67			
Zootoca vivipara [adult] C –> Acheta domesticus [juvenile] O	8	T	L	11.2–32.2	7	0.76	2.77			
	8	T	L	11–32.1	9	0.61	2.26			
	8	T	L	14.6–32.1	7	0.83	3.01			
	8	T	L	14.6–32.2	6	0.88	3.21			
	8	T	L	8.2–32.2	10	1.18	4.88			
	8	T	L	8.3–32.1	9	0.96	3.62			
Surface Area-Specific Dark Respiration Rate (internal)										
Betula pendula [adult] P –> light	188	T	L	-5–40	7	0.58	2.23			
Fagus sylvatica [adult] P –> light	188	T	L	-5–40	8	0.41	1.77			
Surface Area-Specific Foraging Gill Filtration Rate (individual)										
Mytilus edulis [adult] O –> Rhodomonas spp. P	89	M	L	5.9–16.9	8	0.38	1.72			
Surface Area-Specific Maximum Photosynthesis Rate (internal)										
Betula pendula [adult] P –> light	188	T	L	-5–40	7	0.55	2.19			30
Eucalyptus regnans [juvenile] P –> light	181	T	L	10–35	6	0.14	1.21			
	181	T	L	10–35	6	0.16	1.24			30

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\ R}$	E_F	$Q_{10\ F}$	T_{opt}
Fagus sylvatica [adult] P –> light	188	T	L	-5–40	8	0.31	1.56			30
Surface Area-Specific Mitochondrial Respiration Rate (internal)										
Eucalyptus regnans [juvenile] P –> light	181	T	L	10–35	6	0.74	2.66			
Surface Area-Specific Photosynthetic Oxygen Production Rate (internal)										
Embothrium coccineum [adult] P –> light	28	T	L	5–40	8					
	28	T	L	5–40	8	0.52	2.02			30
Gevuina avellana P –> light	28	T	L	5–40	8	0.79	2.98			25
	28	T	L	5–40	8	NS	NS			
Lomatia ferruginea P –> light	28	T	L	5–40	8	0.27	1.45			25
	28	T	L	5–40	8	0.39	NS			25
Voluntary Activity Probability (individual)										
Uta stansburiana [adult] C –> Acheta sp. A [adult] O	178	T	L	20–36	6	0.03	1.04			
Voluntary Body Contraction Rate (individual)										
Aurelia aurita [juvenile] C	40	M	L	10–35	6					25
Voluntary Body Velocity (individual)										
Anisops deanei [adult] C	9	F	L	15–28	4					20
	9	F	L	15–28	4					20
	9	F	L	15–28	4					20
	9	F	L	15–28	4					20
	9	F	L	15–28	4					20
	9	F	L	15–28	4					20
	9	F	L	15–28	4					25
	9	F	L	15–28	4					25
	9	F	L	15–28	4					25
	9	F	L	15–28	4			0.84	0.33	
	9	F	L	15–28	4			0.9	NS	
	9	F	L	15–28	4			NS	NS	
	9	F	L	15–28	4			NS	NS	
	9	F	L	15–28	4	1.03	3.94			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
Astacus astacus [adult] O	95	F	L	0.6–34.4	6	NS	NS	NS	NS	26.1
	95	F	L	-1.3–32	8	NS	NS			20.2
Barbus barbus [adult] O	135	F	L	7–25	4	0.74	2.81			
	135	F	L	7–25	4	NS	NS			
Bembidion lampros [adult] C	31	T	L	5–30	4	NS	NS			
Cataglyphis bicolor [adult] D	71	T	F	29.2–60.1	12	0.16	1.2			
Chionoecetes opilio [adult] C	55	M	L	0–18	7	0.39	1.76			
Culicoides variipennis [juvenile] C	109	F	L	6–36	6	0.52	2.01			
Diaptomus kenai [adult] O	169	F	L	4–22	4	0.19	1.31			
Diaptomus kenai [juvenile] O	169	F	L	4–22	4					14
Dorymyrmex goetschi [adult] O –> sugar microspheres	172	T	F	18.6–37.4	5	0.28	NS			
Gymnocephalus cernuus [adult] C	18	F	L	4–20	5	0.36	1.68			16
Homarus americanus [adult] C	147	M	L	10–25	4	NS	NS			
Micropterus salmoides [adult] C	104	F	L	3–17	8					15
Nucella lapillus [adult] C	99	M	L	5–25	5	0.53	2.12			20
Perca fluviatilis [adult] O	18	F	L	4–20	5	1.28	6.18			
Pterostichus cupreus [adult] C	31	T	L	5–30	5	0.43	1.8			
Solenopsis invicta [adult] O	148	T	F	10.5–32.3	10	0.54	2.05			
Thamnophis sirtalis [adult] C	73	T	L	15.3–33	4	0.07	1.1			
Zygiella x-notata [adult] C	7	T	L	2–20	5	1.15	5.15			
Voluntary Eye Saccade Angular Velocity (individual)										
Girella tricuspidata [adult] H	127	M	L	6.9–14	8	1.24	6			
Voluntary Heart Beat Rate (internal)										
Rana temporaria [adult] C	72	T	L	15.5–29.4	8	0.47	1.88			
	72	T	L	16–29.4	7	0.4	1.69			
	72	T	L	16–29.7	7	0.54	2.06			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\,R}$	E_F	$Q_{10\,F}$	T_{opt}
	72	T	L	17.5–29.7	5	0.54	2.03			
Voluntary Movement Rate (individual)										
Anisops deanei [adult] C	9	F	L	15–28	4					15
	9	F	L	15–28	4					15
	9	F	L	15–28	4					20
	9	F	L	15–28	4					25
Bembidion lampros [adult] C	31	T	L	10–30	4					15
	31	T	L	5–30	5			NS	NS	
	31	T	L	5–30	5	NS	NS			
Chionoecetes opilio [adult] C	55	M	L	0–18	7	1.11	5.06	NS	NS	9
Pterostichus cupreus [adult] C	31	T	L	5–30	5			NS	NS	
	31	T	L	5–30	5	0.3	1.53			20
	31	T	L	5–30	5	NS	NS			
Voluntary Stroke Rate (individual)										
Anisops deanei [adult] C	9	F	L	15–28	4					25
	9	F	L	15–28	4					25
	9	F	L	15–28	4					25
	9	F	L	15–28	4					25
	9	F	L	15–28	4					25
	9	F	L	15–28	4					28
	9	F	L	15–28	4			NS	NS	
	9	F	L	15–28	4			NS	NS	
	9	F	L	15–28	4	0.62	2.29			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			

Trait / Consumer [stage] trophic group –> Resource [stage] trophic group	Cit	Hab	L/F	Temp	N	E_R	$Q_{10\ R}$	E_F	$Q_{10\ F}$	T_{opt}
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
	9	F	L	15–28	4	NS	NS			
Voluntary Tail Beat Rate (individual)										
Culicoides variipennis [juvenile] C	109	F	L	6–36	6	0.42	1.74			
Dendrodoa grossularia [juvenile] O	13	M	L	9.5–18.1	4	0.64	2.47			
Voluntary Tongue Flick Cycle Number (individual)										
Thamnophis elegans vagrans [adult] C	167	T	L	4.9–35	7			0.21	0.76	
Voluntary Tongue Flick Cycle Rate (individual)										
Thamnophis elegans vagrans [adult] C	167	T	L	5.1–34.8	7	0.74	2.75			29.8
	167	T	L	5–34.9	7	0.42	1.76			
Voluntary Tongue Flick Non-Cycle Rate (individual)										
Thamnophis elegans vagrans [adult] C	167	T	L	5.6–35.7	7	0.5	1.98			30.5
Voluntary Wing Beat Rate (individual)										
Coleomegilla fuscilabris [adult] O	134	T	F	28.2–35.9	7	0.11	1.15			
Popillia japonica [adult] H	134	T	F	30.7–40.3	10	0.14	1.19			

Table S4. Results of ANOVA to test effects on mean activation energy, *E,* of rise responses. We do not include motivation because of the strong overlap in some categories in motivation and organization level, for example all responses that are autonomic (motivation) are also internal (level of organization). The effect of taxonomy is examined separately because most traits above the internal and individual organization level consist of multiple taxa. A similar problem arises with trophic level categorization. Because activation energies in most categories are right skewed (Fig. 2b, main text), we log-transformed *E*'s to render them approximately normal (two-tailed, one-sample Kolmogorov-Smirnov test, $p<0.05$) across category combinations. To mitigate imbalances in sample sizes across categories, we combine data from freshwater and marine habitats into a single aquatic category and used Type III sums of squares. This merging of data from marine and freshwater habitats is reasonable because there is no significant difference in mean activation energy between them, and because marine and freshwater environments share many physical properties (11). Figure 2 (main text) shows that the significant effect of organization partially arises from the fact that *E*'s of population traits tend to have higher values than those in other categories. This pattern may also be weakly determined by habitat, as seen by the significant organization x habitat interaction.

Source	Sum Sq.	d.f.	Mean Sq.	F	P-value
Organization	11.238	3	3.746	11.91	0
Habitat	0.025	1	0.02506	0.08	0.7779
Organization × Habitat	2.631	3	0.87692	2.79	0.0408
Error	98.446	313	0.31452		
Total	116	320			

Table S5. Results of ANOVA to test effects on mean optimum temperature, T_{opt}. Methods for this analysis largely follow those for activation energies (Table S4), except that transformation is unnecessary because distributions are approximately normal (two-tailed one-sample Kolmogorov-Smirnov test, $p<0.05$) across category combinations. Results show a significant effect of habitat and organization, as well as significant interactions between them.

Source	Sum Sq.	d.f.	Mean Sq.	F	P-value
Organization	614.8	3	204.94	5.75	0.0008
Habitat	1780.5	1	1780.48	49.92	0
Organization × Habitat	324.5	3	108.16	3.03	0.0301
Error	8239.8	231	35.67		
Total	14652.7	238			

Table S6. Data sources. Numbers on left correspond to citation codes (**Cit**) in Table S3.

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