

1   **Supporting Information for**  
2   Optimum growth temperature declines with body size within fish species

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## 54    **Literature search, selection process and criteria**

55    This section is an overview of the literature search approach, and below we present the search  
56    terms for each rate separately (maximum consumption, metabolism and growth). In addition  
57    to search terms, we also applied filters by selecting only the following subjects: ‘marine  
58    freshwater biology’, ‘fisheries’, ‘ecology’, ‘zoology’, ‘biology’, ‘physiology’. For growth  
59    rates, we also included ‘limnology’ and for maximum consumption we included ‘limnology’  
60    and ‘evolutionary biology’. The use of additional subjects for growth and consumption reflects  
61    the lower data availability compared to metabolism. As we suspected that relatively few studies  
62    would have considered both body size- and temperature treatments, our goal was to get an as  
63    extensive as possible list of studies. Therefore, we also evaluated articles cited by articles found  
64    in the search, from published review-type articles and reviews of applications of bioenergetics  
65    models such as the Wisconsin model <sup>1</sup>, and if the study was found in the literature search for  
66    another rate. The source of the article (WoS search or cited in literature) is indicated in the data  
67    sets (Table S1).

68    Articles were filtered out at three levels of the search: title, abstract and full article. The  
69    online repository of this project (<https://github.com/maxlindmark/scaling>) contains .txt files of  
70    the complete list of articles found in the literature search. We removed studies from the lists if  
71    the titles made it clear the articles did not fulfil all of the following conditions: (1) experimental  
72    study, (2) fish as study organism in post-larval life stages, and (3) replicates across both body  
73    size and temperature (factorially). We treat data as individual-level rates (per fish); however,  
74    in some cases they were measured as averages across multiple individuals. In addition to these  
75    general criteria, we also had criteria specific for each rate (see below). When several studies  
76    were found for the same species, we did not include all but instead chose the study with the  
77    largest body size and temperature range (in that order), as there can be large differences in  
78    absolute values of some physiological parameters between studies.

79 For consumption and growth rate, we determined if each data point within species was  
80 below or beyond peak temperature either by using information provided by the authors (e.g. by  
81 deriving a polynomial regression of the rate as a function of temperature to find the temperature  
82 of peak rate), by fitting quadratic models or visually inspecting data for each species separately.  
83 Whether a data point was below or above peak or optimum temperatures is indicated by a  
84 separate column in the data (Table S1).

85

86 ***Maximum consumption rate***

87 We used the following topic terms for maximum consumption rate (three searches in total):  
88 (consumption OR bioenerg\* OR ingestion OR “food-intake”) AND (mass OR weight OR size)  
89 AND (temperature\*), as well as: (feeding-rate OR bio-energ\*) AND (mass OR weight OR  
90 size) AND (temperature\*) and lastly: (“food intake”) AND (mass OR weight OR size) AND  
91 (temperature\*). \* represents any group of characters, including no character. The searches for  
92 maximum consumption rate data resulted in 15259 articles (search date: 18 December 2018),  
93 with 3449 remaining after filtering by subject categories. The second search (search date: 13  
94 March 2019) resulted in 431 additional titles after filtering by subject categories (of which  
95 some where duplicated from the first search) and the third search (search date: 29 June 2020)  
96 yielded 626 but no additional articles as they had either been selected already or did not meet  
97 the criteria. Articles were filtered out at the abstract and whole article stage if the original  
98 reference could not be identified and evaluated, if data were normalized (i.e., using a priori  
99 defined scaling relationships to show corrected data rather than measured values), there was no  
100 acclimation, or if measurements were not maximum consumption rate. As with the growth  
101 data, definitions of ad-libitum feeding may differ between studies – the key for our purpose is  
102 that food rations led to satiation and were not limiting. Consumption rates were converted to

103 g day<sup>-1</sup> (but note we fitted models to mass-specific rates, g g<sup>-1</sup> day<sup>-1</sup>). These data were  
104 compiled in the file consumption\_data.xlsx.

105

106 ***Metabolic rate***

107 We used the following topic terms for metabolic rate data: (metabolism OR "oxygen-  
108 consumption" OR "oxygen consumption") AND (mass OR weight OR size) AND  
109 (temperature\*). \* represents any group of characters, including no character. The search for  
110 metabolic rate experiments resulted in 8405 articles (search date: 6 June 2019), which was  
111 reduced to 3458 after applying filters for subject categories. Articles were filtered out at the  
112 abstract and whole article stage if the original reference could not be identified and evaluated,  
113 if data were normalized (i.e., using a priori defined scaling relationships to normalize data for  
114 data a given size rather than measured values), if there was no acclimation or if it was not  
115 standard, routine or resting metabolic rate. The latter was defined as oxygen consumption of  
116 an unfed fish at no or little spontaneous activity. Metabolic rates were converted to mg O<sub>2</sub> h<sup>-1</sup>,  
117 because it was the most common unit in the data set (but note models were fitted to mass-  
118 specific rates, mg O<sub>2</sub> g<sup>-1</sup> h<sup>-1</sup>). These data were compiled in the file metabolism\_data.xlsx.

119

120 ***Growth rates & optimum temperature for growth over body mass***

121 Growth rates were taken from data found in the literature search for optimum growth  
122 temperatures. Therefore, articles in which growth rates were measured at sub-optimum  
123 temperatures only were not included (note this is in contrast to consumption data where  
124 "optimum" was not included in the search terms). We used the following topic terms for growth  
125 rate data: (growth) AND (mass OR weight OR size) AND (temperature\*) AND (optimum), as  
126 well as: (growth) AND (mass OR weight OR size) AND (temperature\*) AND (optim\*). \*  
127 represents any group of characters, including no character. The two searches for growth rates

128 resulted in 3313 articles (search date: 22 March 2019), and 3747 articles (search date: 5 May  
129 2019), respectively. After applying additional filters by subject category, we acquired 566 and  
130 893 studies, respectively (of which some are duplicates due to similar search-strings). We  
131 removed studies at the abstract and whole article stage where the original reference could not  
132 be identified and evaluated, if we could not extract actual growth rates, if there was not a  
133 controlled temperature for each growth trial, or if there were not multiple defined size-classes.  
134 We used only one observation (data point) per size class and temperature treatment, and in  
135 cases where there were two, we used the mean value. In addition, we ensured that no other  
136 treatment (e.g., food limitation) confounded the response variable and thus only used data from  
137 experiments with satiating food levels. Body mass is either the geometric mean of the initial  
138 and final mass of the growth trial or the size class, depending on data availability (see Table  
139 S1). It is important to control for feeding rations as it affects the temperature optimum for  
140 growth<sup>2</sup>. This was achieved in different ways in the different experimental studies, but  
141 commonly involved excess feeding rations once or several times per day. The key description  
142 we looked for in the study was that food was not limiting. We treat data as individual-level  
143 growth (per fish); however, these were commonly measured as averages for multiple  
144 individuals. In the case growth was length-based, we converted it to mass using weight-length  
145 relationships from FishBase<sup>3,4</sup>. We compiled two separate data sets: raw growth rates  
146 (growth\_data.xlsx) and temperature at optimum growth (growth\_data\_Topt.xlsx). In the latter,  
147 we defined optimum temperature for growth as the fitted optimum temperature by size-class  
148 (usually estimated in the original study). Therefore, the optimum temperature may not always  
149 correspond to an actual experimental temperature but could be an estimation. If the optimum  
150 temperature (by size group) was not estimated in the original study, we used the temperature  
151 where growth rate was maximized. All growth rates were expressed in unit % day<sup>-1</sup>.

152 **Table S1** Explanation of data columns (G=growth data, T<sub>opt</sub>=optimum growth temperature

153 data, C=maximum consumption data, M=metabolism data).

Column	Explanation	Datasets
<i>growth_rate_%/day</i>	Main response variable.	G, T <sub>opt</sub>
<i>opt_temp_c</i>	Main response variable.	T <sub>opt</sub>
<i>initial_mass_g</i>	Body mass [g] at the onset of the growth trial.	G, T <sub>opt</sub>
<i>final_mass_g</i>	Body mass [g] at the end of the growth trial.	G, T <sub>opt</sub>
<i>geom_mean_mass_g</i>	Geometric mean mass in t <sub>1</sub> and t <sub>2</sub> of the growth trial.	G, T <sub>opt</sub>
<i>size_group</i>	Representative body mass of size group in the growth trial, in case initial, final or geometric body mass could not be retrieved.	G, T <sub>opt</sub>
<i>consumption</i>	Main response variable.	C
<i>metabolic_rate</i>	Main response variable.	M
<i>type</i>	Type of respiration measurement (resting, routine, standard).	M
<i>unit</i>	Unit of response variable.	C, M
<i>original_unit</i>	Original unit of response variable. If different from “ <i>unit</i> ”, see “ <i>notes</i> ” column for information on conversion.	C, M
<i>mass_g</i>	Body mass in experiment [g]. Some studies report body masses before and some after the feeding trials. See “ <i>notes</i> ”.	C, M
<i>temp_c</i>	Experimental temperature [°C].	G, C, M
<i>above_peak_temp</i>	Is the experiment conducted at temperature above peak temperature for the given size group? Y/N.	G, C, M
<i>common_name</i>	Common name of species.	G, T <sub>opt</sub> , C, M
<i>species</i>	Scientific name of species.	G, T <sub>opt</sub> , C, M
<i>genus</i>	Genus of species.	G, T <sub>opt</sub> , C, M
<i>family</i>	Family of species.	G, T <sub>opt</sub> , C, M
<i>order</i>	Order of species.	G, T <sub>opt</sub> , C, M
<i>habitat</i>	Species natural habitat, taken from FishBase <sup>4</sup> .	G, T <sub>opt</sub> , C, M
<i>lifestyle</i>	Lifestyle of species, taken from FishBase <sup>4</sup> .	G, T <sub>opt</sub> , C, M
<i>biogeography</i>	Biogeography of species, taken from FishBase <sup>4</sup> .	G, T <sub>opt</sub> , C, M
<i>trophic_level</i>	Trophic level of species, taken from FishBase <sup>4</sup> .	G, T <sub>opt</sub> , C, M
<i>w_maturity_g</i>	Body mass [g] at maturation taken from FishBase	G, T <sub>opt</sub>

	<sup>4</sup> . If not available, weight was estimated from length using species-specific allometric weight-length, else taken from alternative sources (see "notes"). Used to estimate relative body size across species in the data and to normalized optimum growth temperatures across species.	
<i>w_max_published_g</i>	Max. published weight [g] taken from FishBase <sup>4</sup> . If not available, weight was estimated from length using species-specific allometric weight-length, else taken from alternative sources (see "notes"). Used to estimate relative body size across species in the data.	G, T <sub>opt</sub> , C, M
<i>env_temp_min</i>	Min. environmental temperature [°C], taken from FishBase <sup>4</sup> . If not available on FishBase, data were taken from alternative sources (see "notes"). Used to compare experimental temperatures to common temperatures for species.	G, T <sub>opt</sub> , C, M
<i>env_temp_max</i>	Max. environmental temperature [°C], taken from FishBase <sup>4</sup> . If not available on FishBase, data were taken from alternative sources (see "notes"). Used to compare experimental temperatures to common temperatures for species.	G, T <sub>opt</sub> , C, M
<i>env_temp_mid</i>	Median of environmental temperature [°C], taken from FishBase <sup>4</sup> . If not available on FishBase, data were taken from alternative sources (see "notes"). Used to compare experimental temperatures to common temperatures for species.	G, T <sub>opt</sub> , C, M
<i>pref_temp_mid</i>	Median of preferred temperature [°C], taken from FishBase <sup>4</sup> . If not available on FishBase, data were taken from alternative sources (see "notes"). Used to compare experimental temperatures to common temperatures for species.	G, T <sub>opt</sub> , C, M
<i>notes</i>	This column contains additional information, including if data were sent by authors, if any column above has data that is not from the main source (i.e. FishBase), how certain metrics were calculated, alternative common names, comments on the experimental protocol, information on conversion to standard "unit", source of the data (literature search or cited in paper from literature search)	G, T <sub>opt</sub> , C, M
<i>reference</i>	Source (See Table S2).	G, T <sub>opt</sub> , C, M

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155 **Table S2** Species, common name, the data set(s) in which they appear and the sources  
 156 (G=growth data, T<sub>opt</sub>=optimum growth temperature data, C=maximum consumption data,  
 157 M=metabolism data). If more than one data and source, the sources are in order (1 study per

158 species and rate).

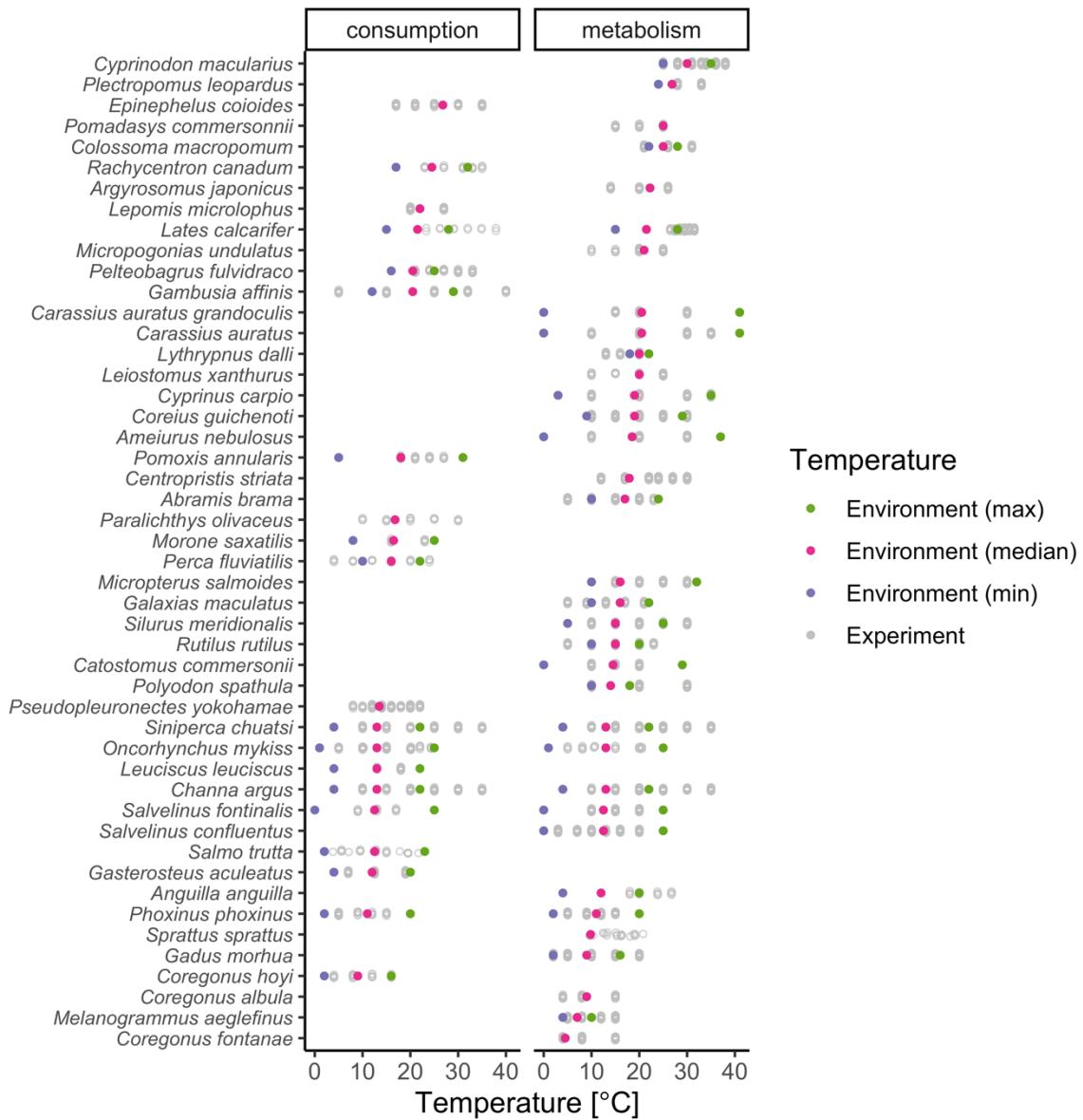
Species	Common name	Datasets	Source
<i>Pseudopleuronectes yokohamae</i>	Marbled flounder	G, T <sub>opt</sub> , C	<sup>5</sup>
<i>Cyclopterus lumpus</i>	Lumpfish	G, T <sub>opt</sub>	<sup>6</sup>
<i>Paralichthys olivaceus</i>	Japanese flounder (alt. bastard halibut, Japaneese halibut or Olive flounder)	G, T <sub>opt</sub> , C	<sup>7</sup>
<i>Salvelinus alpinus</i>	Arctic char	G, T <sub>opt</sub>	<sup>8</sup>
<i>Salmo salar</i>	Atlantic salmon	G, T <sub>opt</sub>	<sup>9</sup>
<i>Lates calcarifer</i>	Barramundi	G, T <sub>opt</sub> , C, M	<sup>10</sup> <sup>10</sup> <sup>10</sup> <sup>11</sup>
<i>Gadus morhua</i>	Atlantic cod	G, T <sub>opt</sub> , M	<sup>12</sup> <sup>13</sup>
<i>Hippoglossus hippoglossus</i>	Atlantic halibut	G, T <sub>opt</sub>	<sup>14</sup>
<i>Scophthalmus maximus</i>	Turbot	G, T <sub>opt</sub>	<sup>15</sup>
<i>Boreogadus saida</i>	Arctic cod	G, T <sub>opt</sub>	<sup>16</sup>
<i>Rachycentron canadum</i>	Cobia	G, T <sub>opt</sub> , C	<sup>17</sup>
<i>Pelteobagrus fulvidraco</i>	Yellow catfish	G, T <sub>opt</sub> , C	<sup>18</sup>
<i>Anarhichas minor</i>	Spotted wolffish	G, T <sub>opt</sub>	<sup>19</sup>
<i>Oncorhynchus mykiss</i>	Rainbow trout	C, M	<sup>20</sup>
<i>Perca fluviatilis</i>	Eurasian perch	C	<sup>21</sup>
<i>Phoxinus phoxinus</i>	Eurasian minnow	C, M	<sup>22</sup>
<i>Coregonus hoyi</i>	Bloater	C	<sup>23</sup>
<i>Pomoxis annularis</i>	White crappie	C	<sup>24</sup>
<i>Gambusia affinis</i>	Western mosquitofish	C	<sup>25</sup>
<i>Morone saxatilis</i>	Striped bass	C	<sup>26</sup>
<i>Salvelinus fontinalis</i>	Brook trout	C, M	<sup>27</sup> <sup>28</sup>
<i>Leuciscus leuciscus</i>	Dace	C	<sup>29</sup>
<i>Lepomis microlophus</i>	Redear sunfish	C	<sup>30</sup>
<i>Channa argus</i>	Chinese snakehead (alt. Northern snakehead or Snakehead)	C, M	<sup>31</sup> <sup>32</sup>
<i>Siniperca chuatsi</i>	Mandarin fish	C, M	<sup>31</sup> <sup>32</sup>
<i>Gasterosteus aculeatus</i>	Three-spined stickleback	C	<sup>33</sup>
<i>Salmo trutta</i>	Brown trout	C	<sup>34</sup>
<i>Epinephelus coioides</i>	Orange-spotted grouper	C	<sup>40</sup> – <sup>42</sup> <sup>35</sup>
<i>Coregonus albula</i>	Vendace	M	<sup>36</sup>
<i>Coregonus fontanae</i>	Stechlin cisco	M	<sup>36</sup>
<i>Abramis brama</i>	Common bream	M	<sup>36</sup>
<i>Rutilus rutilus</i>	Common roach	M	<sup>36</sup>
<i>Salvelinus confluentus</i>	Bull trout	M	<sup>37</sup>
<i>Catostomus commersonii</i>	White sucker	M	<sup>28</sup>
<i>Cyprinus carpio</i>	Common carp	M	<sup>28</sup>
<i>Ameiurus nebulosus</i>	Brown bullhead	M	<sup>28</sup>
<i>Silurus meridionalis</i>	Southern catfish	M	<sup>38</sup>

<i>Carassius auratus</i>	Goldfish	M	39
<i>Pomadasys commersonnii</i>	Spotted grunter	M	40
<i>Melanogrammus aeglefinus</i>	Haddock	M	41
<i>Centropristes striata</i>	Black sea bass	M	42
<i>Anguilla anguilla</i>	European eel	M	43
<i>Micropterus salmoides</i>	Largemouth bass	M	44
<i>Cyprinodon macularius</i>	Desert pupfish	M	45
<i>Micropogonias undulatus</i>	Atlantic croaker	M	46
<i>Leiostomus xanthurus</i>	Spot	M	46
<i>Coreius guichenoti</i>	Largemouth bronze gudgeon	M	47
<i>Sprattus sprattus</i>	European sprat	M	48
<i>Plectropomus leopardus</i>	Leopard coral grouper	M	49
<i>Galaxias maculatus</i>	Common galaxias	M	50
<i>Polyodon spathula</i>	American paddlefish (alt. Mississippi paddlefish)	M	51
<i>Argyrosomus japonicus</i>	Mulloway	M	52
<i>Lythrypnus dalli</i>	Bluebanded goby	M	53
<i>Colossoma macropomum</i>	Tambaqui (alt. Cachama)	M	54
<i>Carassius auratus grandoculis</i>	Round crucian carp (alt. Nigorobuna)	M	55

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160 **Data overview**

161 **Maximum consumption & metabolic rate**

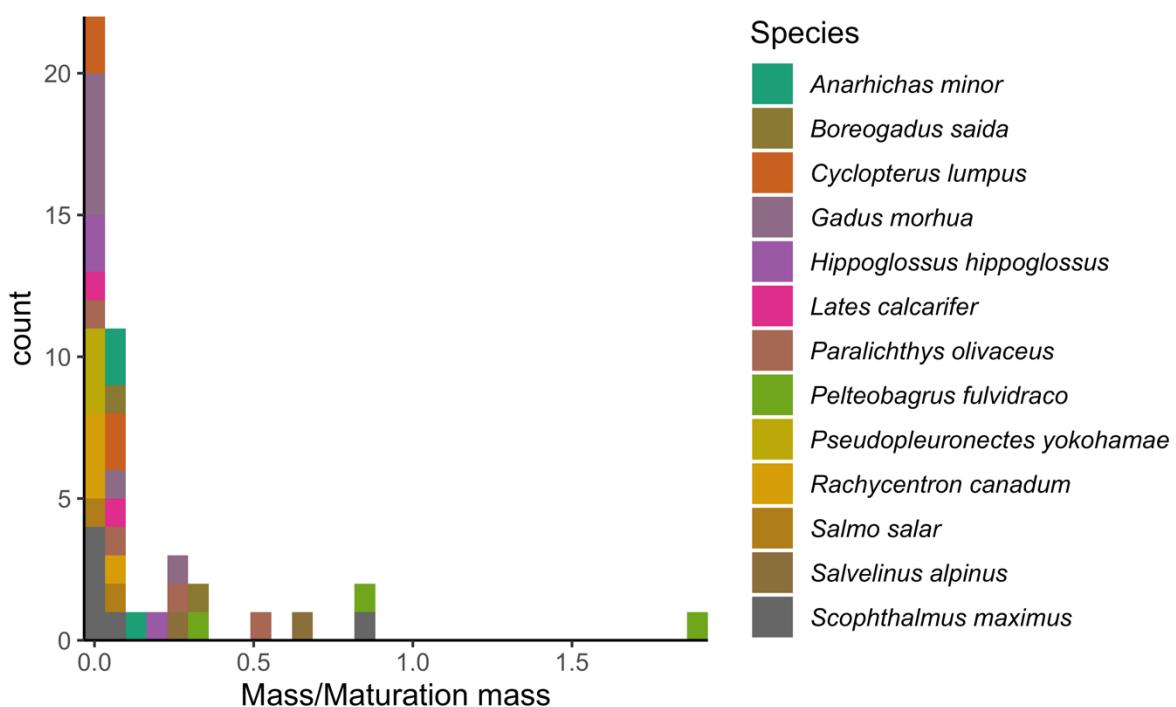


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163 *Fig. S1. Experimental temperatures (gray) and environmental (min, median and max)*  
 164 *temperatures (purple, pink and green, respectively) of species represented in the consumption*  
 165 *(left) and metabolism (right) data sets. Missing temperatures means information was not*  
 166 *available on FishBase. Experimental temperatures are jittered vertically for visibility.*

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171 *Fig. S2. The distribution of rescaled masses for individual observations (mass/mass at  
172 maturation), where color indicate species.*

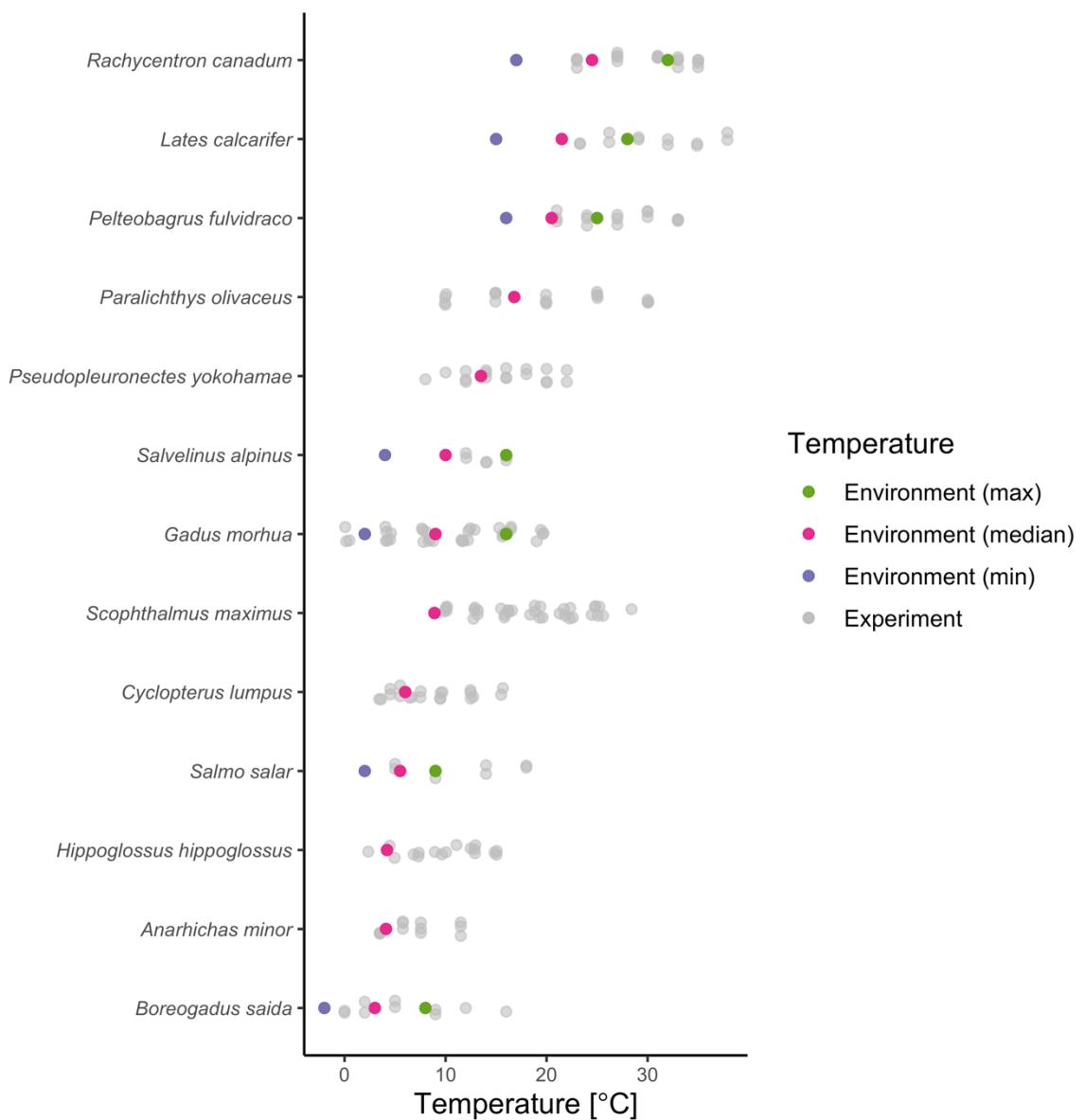
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179 *Fig. S3. Experimental temperatures (gray) in the growth rate data and environmental (min,*  
 180 *median and max) temperatures (purple, pink and green, respectively). Missing temperatures*  
 181 *means information was not available on FishBase. Experimental temperatures are jittered*  
 182 *vertically for visibility.*

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187 **Supplementary methods and analysis**

188 At below peak temperatures, the intraspecific mass- and temperature dependence of specific  
189 growth (% increase in size day<sup>-1</sup>) can be described by the equation:  $\ln(G) = 0.5 -$   
190  $0.36 \times \ln(m) - 0.74 \times t_A + 0.0046 \times t_A \times \ln(m)$  (Fig. S12), based on posterior medians of  
191 the global parameters, thus representing an average (unmeasured) fish. (see Fig S15, S19, S23  
192 and S27 for the full posteriors distributions of parameters for all models). The mass exponent  
193 of growth is estimated to be -0.36 [-0.5, -0.23] and the activation energy ( $-\mu_{\beta_2}$ ) of growth 0.74  
194 [0.95, 0.53]. This is similar to the predicted mass scaling of net energy at sub-optimum  
195 temperatures, defined as the difference between consumption and metabolism (Fig. 3; see also  
196 methods on '*Net energy gain*'), which scales with a mass-specific exponent of -0.38. The  
197 estimated temperature-mass interaction coefficient is both small and uncertain (0.0046 [-0.064,  
198 0.075]), where Bayesian 95% credible intervals are indicated in square brackets.

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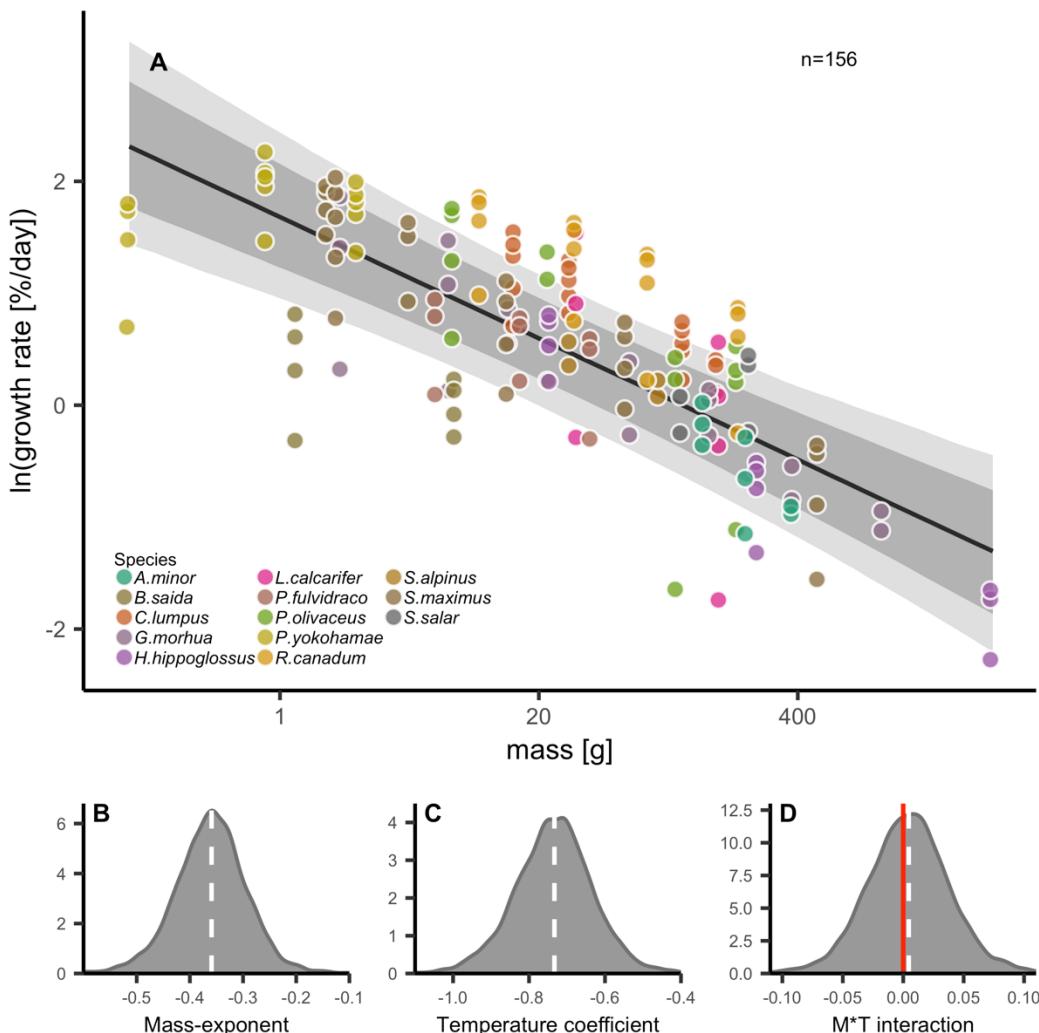
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210 *Fig. S4. Effects of temperature and body mass on body growth below optimum temperature.*

211 *Panel A) shows the natural log of specific growth rate as a function of body mass on a*  
 212 *logarithmic x-axis (for readability, note the model is fitted with  $\ln(\text{mass})$  as a predictor), such*  
 213 *that the slope corresponds to the mass-scaling exponent. Colors indicate species. The line in*  
 214 *panel A is the global prediction from model M1 at the mean temperature in the growth data*  
 215 *(14°C, but note the model is fitted using Arrhenius temperature). Shaded areas correspond to*  
 216 *80% and 95% credible intervals. Point colors indicate species. The bottom row shows the*  
 217 *posterior distributions for (B) the global mass-scaling exponent,  $\mu_{\beta_1}$ , (C) the global*  
 218 *temperature coefficient,  $\mu_{\beta_2}$  and (D) the global mass-temperature interaction,  $\mu_{\beta_3}$ . Dashed*  
 219 *white line shows the posterior median and red vertical line in (D) indicates zero.*

220 **Table S3** Description of model parameters (type and their interpretation in brackets) and their  
 221 prior distributions (see ‘*Model description*’ and equations 1-3 in the main text).  $N$  refers to a  
 222 normal distribution (mean and standard deviation, s.d.) and  $U$  to a uniform distribution  
 223 (interval). For simplicity, only the parameters of the full model are shown here (i.e., with most  
 224 coefficients varying by species), but note that when a model is fitted with a common rather  
 225 than species-varying coefficient, for example  $\beta_1$  instead of  $\beta_{1j} \sim N(\mu_{\beta_1}, \sigma_{\beta_1})$ , we use the same  
 226 prior for  $\beta_1$  as for  $\mu_{\beta_1}$ .

Model	Parameter	Description	Prior distribution
<b>Log-linear regressions for growth, consumption and metabolism</b>	$\mu_{\beta_{0s}}$	Hyperparameter (average intercept for standard metabolic rate across species) <i>Only for metabolism model.</i>	$N(-2, 5)$
	$\mu_{\beta_{0r}}$	Hyperparameter (average intercept for routine and resting metabolic rate across species). <i>Only for metabolism model.</i>	$N(-1, 5)$
	$\mu_{\beta_0}$	Hyperparameter (average intercept across species). <i>Only for consumption and growth models.</i>	$N(0, 5)$
	$\mu_{\beta_1}$	Hyperparameter (average mass coefficient across species)	$N(-0.25, 1)$
	$\mu_{\beta_2}$	Hyperparameter (average temperature coefficient across species)	$N(-0.6, 1)$
	$\mu_{\beta_3}$	Hyperparameter (average interaction coefficient across species)	$N(0, 1)$
	$\sigma_{\beta_{0s}}$	Hyperparameter (s.d. of species-intercepts for standard metabolic rate)	$U(0, 10)$
	$\sigma_{\beta_{0r}}$	Hyperparameter (s.d. of species-intercepts for routine and resting metabolic rate)	$U(0, 10)$
	$\sigma_{\beta_1}$	Hyperparameter (s.d. of species mass coefficients)	$U(0, 10)$
	$\sigma_{\beta_2}$	Hyperparameter (s.d. of species temperature coefficients)	$U(0, 10)$
	$\sigma_{\beta_3}$	Hyperparameter (s.d. of species interaction coefficients)	$U(0, 10)$
	$\sigma$	Parameter (s.d.)	$U(0, 10)$
<b>Sharpe-Schoolfield (unimodal consumption data)</b>	$\mu_{c_{0j}}$	Hyperparameter (average consumption at reference temperature [-10 on centered scale] across species)	$N(1, 1)$
	$\mu_{E_j}$	Hyperparameter (average activation energy across species)	$N(0.5, 0.5)$

	$E_h$	Parameter (common rate of decline with temperature)	$N(2, 2)$
	$T_h$	Parameter (common temperature at which half the rate is reduced due to high temperatures)	$N(5, 2)$
	$\sigma_{E_j}$	Hyperparameter (s.d. of species-varying activation energies)	$U(0, 3)$
	$\sigma_{C_0j}$	Hyperparameter (s.d. of species-varying average consumption)	$U(0, 3)$
	$\sigma$	Parameter (s.d.)	$U(0, 3)$
<b>Linear <math>T_{opt}</math> models</b>	$\mu_{\beta_0}$	Hyperparameter (average intercept across species)	$N(0, 5)$
	$\mu_{\beta_1}$	Hyperparameter (average mass coefficient across species)	$N(0, 5)$
	$\sigma_{\beta_0}$	Hyperparameter (s.d. of species-intercepts)	$U(0, 10)$
	$\sigma_{\beta_1}$	Hyperparameter (s.d. of species mass coefficients)	$U(0, 10)$
	$\sigma$	Parameter (s.d.)	$U(0, 10)$

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243 **Table S4.** Model comparison for the log-linear regressions of how consumption, metabolism  
 244 and growth depend on mass and temperature below optimum temperatures (see ‘*Model*  
 245 *description*’ and equations 1-3 in the main text). The column m\*t indicates whether the model  
 246 for the rate includes an interactive effect of mass and temperature. The models differ in which  
 247 coefficients vary among species and which are common, where  $\beta_0$  is the intercept,  $\beta_1$  mass  
 248 coefficient (mass-exponent on linear scale),  $\beta_2$  temperature coefficient (corresponding to the  
 249 negative activation energy) and  $\beta_3$  interaction between mass and temperature. The WAIC  
 250 columns shows  $\Delta$ WAIC and absolute WAIC in brackets, rounded to the nearest decimal, where  
 251  $\Delta$ WAIC is the difference between each models’ WAIC and the lowest WAIC across models.  
 252 Bold indicates models with  $\Delta$ WAIC < 2.

Model	m*t	Species-varying parameter(s)	WAIC metabolism	WAIC consumption	WAIC growth
<b>M1</b>	Yes	$\beta_0, \beta_1, \beta_2, \beta_3$	<b>0 (273.2)</b>	4.3 (564.5)	<b>0 (47.2)</b>
<b>M2</b>		$\beta_0, \beta_1, \beta_2$	<b>1.27 (274.5)</b>	3.1 (563.4)	7.2 (54.4)
<b>M3a</b>		$\beta_0, \beta_1$	306.1 (579.3)	148.1 (708.4)	23.4 (70.6)
<b>M3b</b>		$\beta_0, \beta_2$	387.5 (660.7)	70.1 (630.4)	32.6 (79.8)
<b>M4</b>		$\beta_0$	649.6 (922.8)	189.9 (750.2)	43.5 (90.7)
<b>M5</b>	No	$\beta_0, \beta_1, \beta_2$	5.0 (278.2)	<b>0 (560.2)</b>	5.5 (52.7)
<b>M6a</b>		$\beta_0, \beta_1$	347.8 (621.0)	166.1 (726.3)	22.1 (69.3)
<b>M6b</b>		$\beta_0, \beta_2$	388.9 (662.1)	74.1 (634.4)	34.3 (81.5)
<b>M7</b>		$\beta_0$	682.2 (955.4)	213.9 (774.2)	44.9 (92.1)

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258 **Table S5.** Comparison of the two models fitted to optimum growth temperature data. The  
259 WAIC columns shows  $\Delta$ WAIC and absolute WAIC in brackets, rounded to the nearest decimal,  
260 where  $\Delta$ WAIC is the difference between each models' WAIC and the lowest WAIC across  
261 models. Bold indicates models with  $\Delta$ WAIC < 2.

Model	Species-varying parameter(s)	WAIC
<b>M1</b>	$\beta_0, \beta_1$	<b>0 (177.3)</b>
<b>M2</b>	$\beta_0$	<b>1 (178.3)</b>

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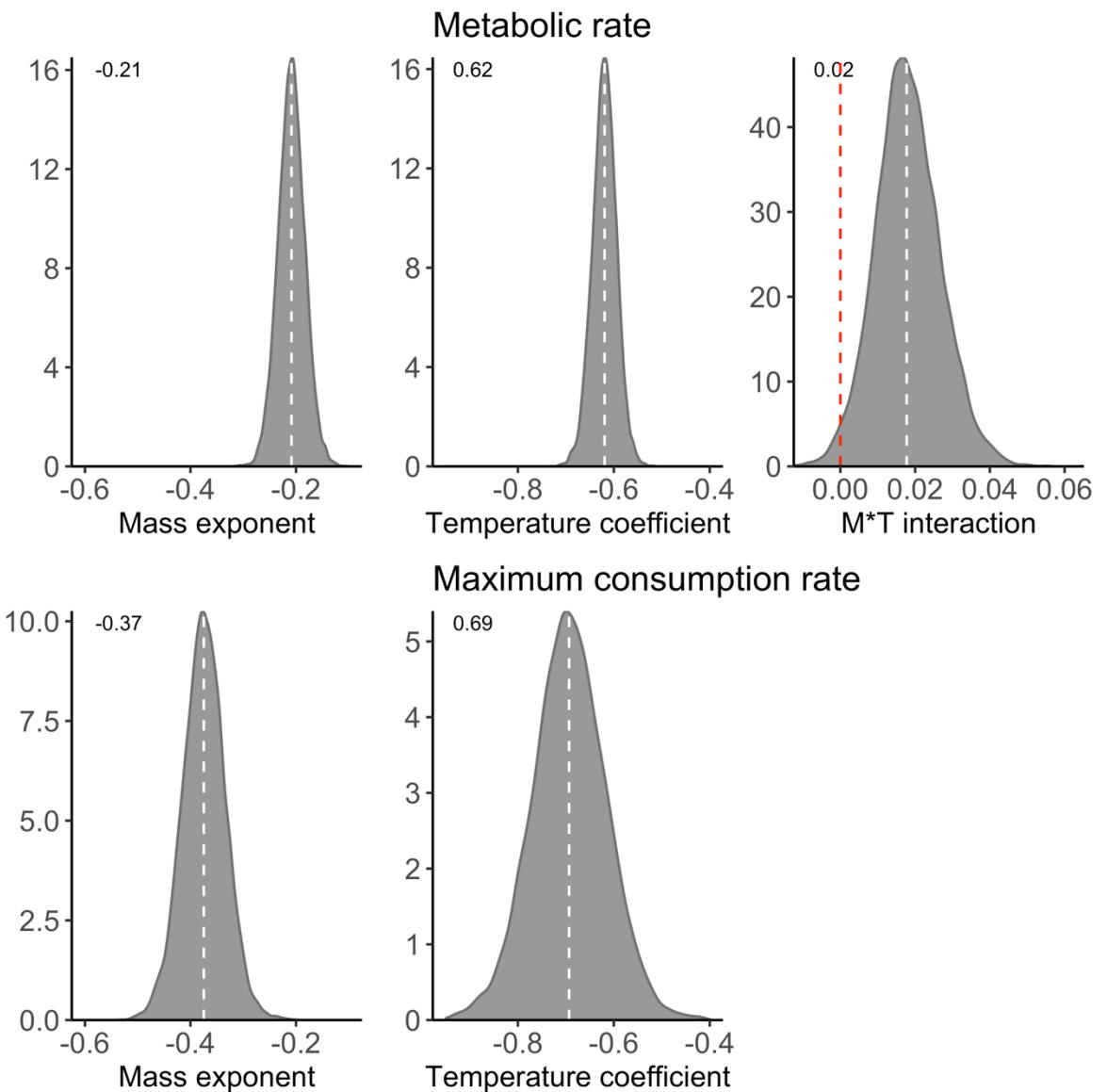
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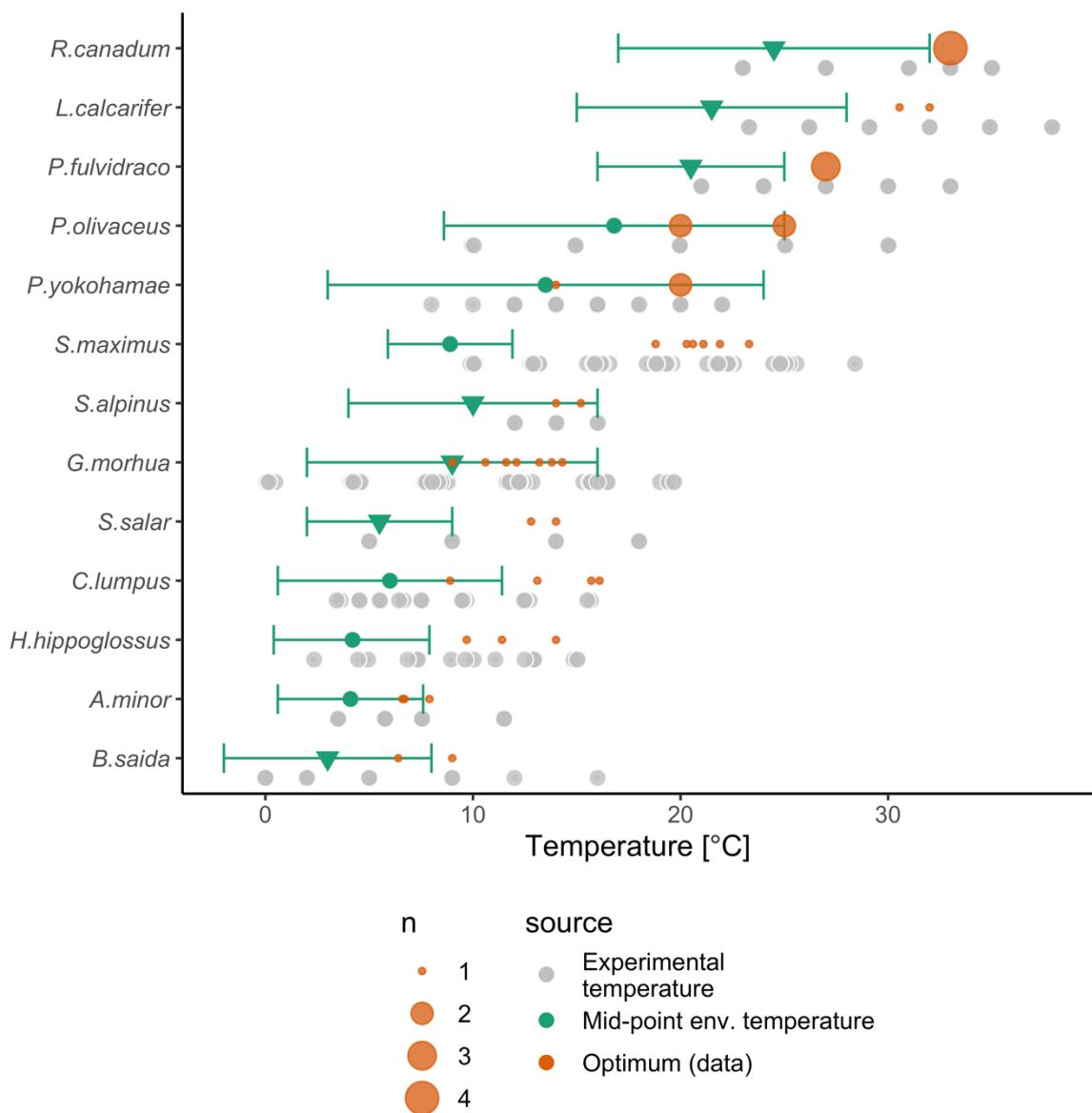


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282 *Fig. S5. Posterior distributions of the global intraspecific mass-specific mass exponents ( $\mu_{\beta_1}$ )*  
 283 *and temperature coefficients ( $\mu_{\beta_2}$ ) for metabolic rate (top) and maximum consumption rate*  
 284 *(bottom). For metabolism, the global interaction coefficient ( $\mu_{\beta_3}$ ) is also shown (estimated and*  
 285 *presented on an Arrhenius temperature scale), but for consumption this term was not included*  
 286 *in the selected model. Numbers in the top left corner correspond to the posterior median. The*  
 287 *axes are the same for each parameter for comparison between the two rates.*

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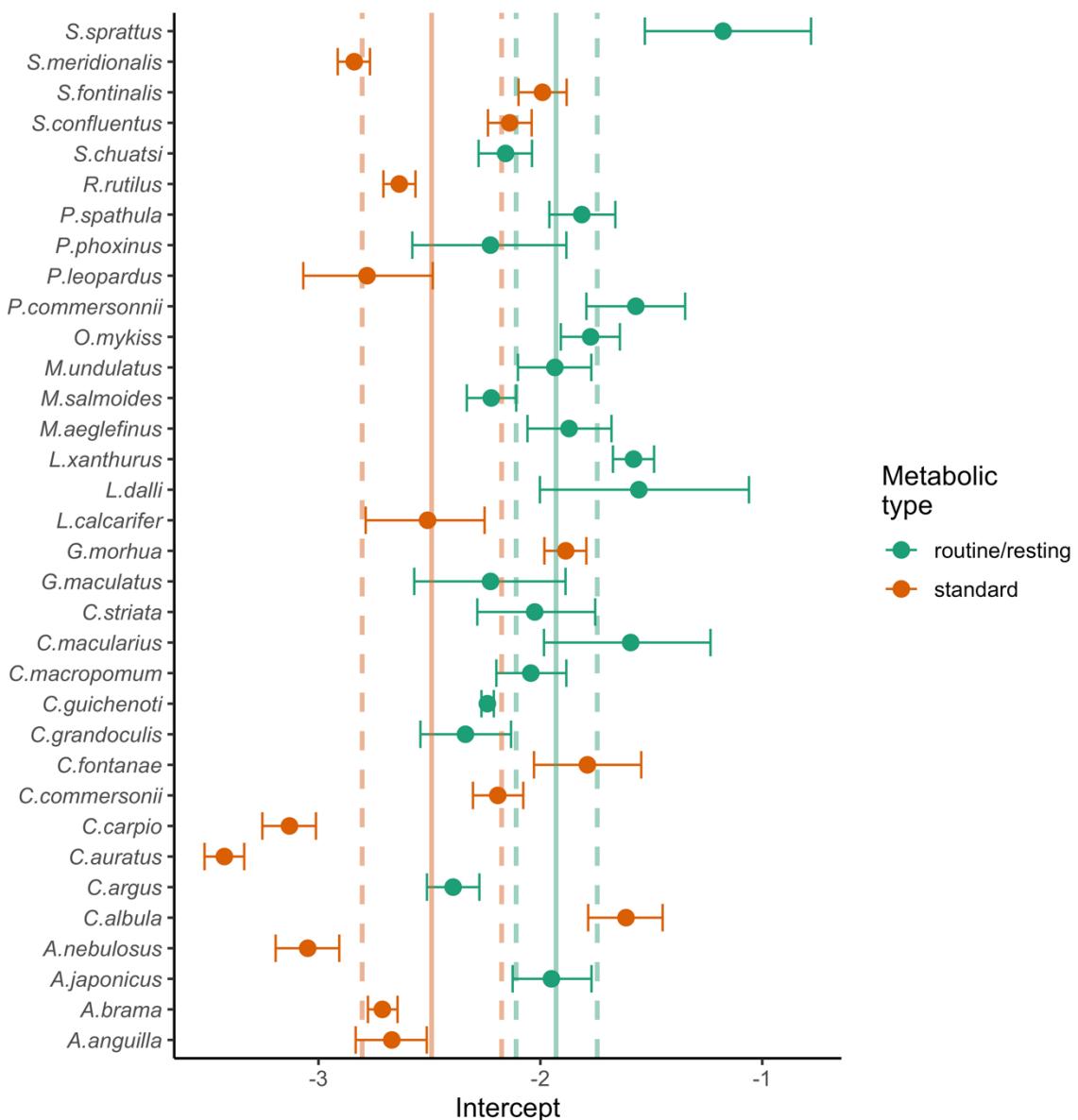
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291 *Fig. S6. Experimental temperatures (grey) overlap environmental temperatures (green), and*  
 292 *optimum growth temperatures (orange) are typically at the upper end or above the*  
 293 *environmental range. Horizontal green lines show the minimum and maximum environmental*  
 294 *temperature based on either temperature in distribution range (triangles) or modelled*  
 295 *distribution maps (circles), both taken from FishBase. The optimum growth temperatures are*  
 296 *depicted for all size-classes per species, where the circle size is proportional to number of*  
 297 *observations at that temperature.*

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300 *Fig. S7. Posterior median of species-level intercepts (points) and their 95% credible interval*  
 301 *(horizontal error bars). Colors indicate the type of metabolism measurement for each species.*  
 302 *Vertical solid lines are the posterior medians of the global intercepts (orange for standard*  
 303 *metabolic rate,  $\mu_{\beta_0s}$ , and green for routine or resting metabolic rate,  $\mu_{\beta_{0r}}$ ), and the dashed*  
 304 *vertical lines show the 95% credible intervals for the global parameters.*

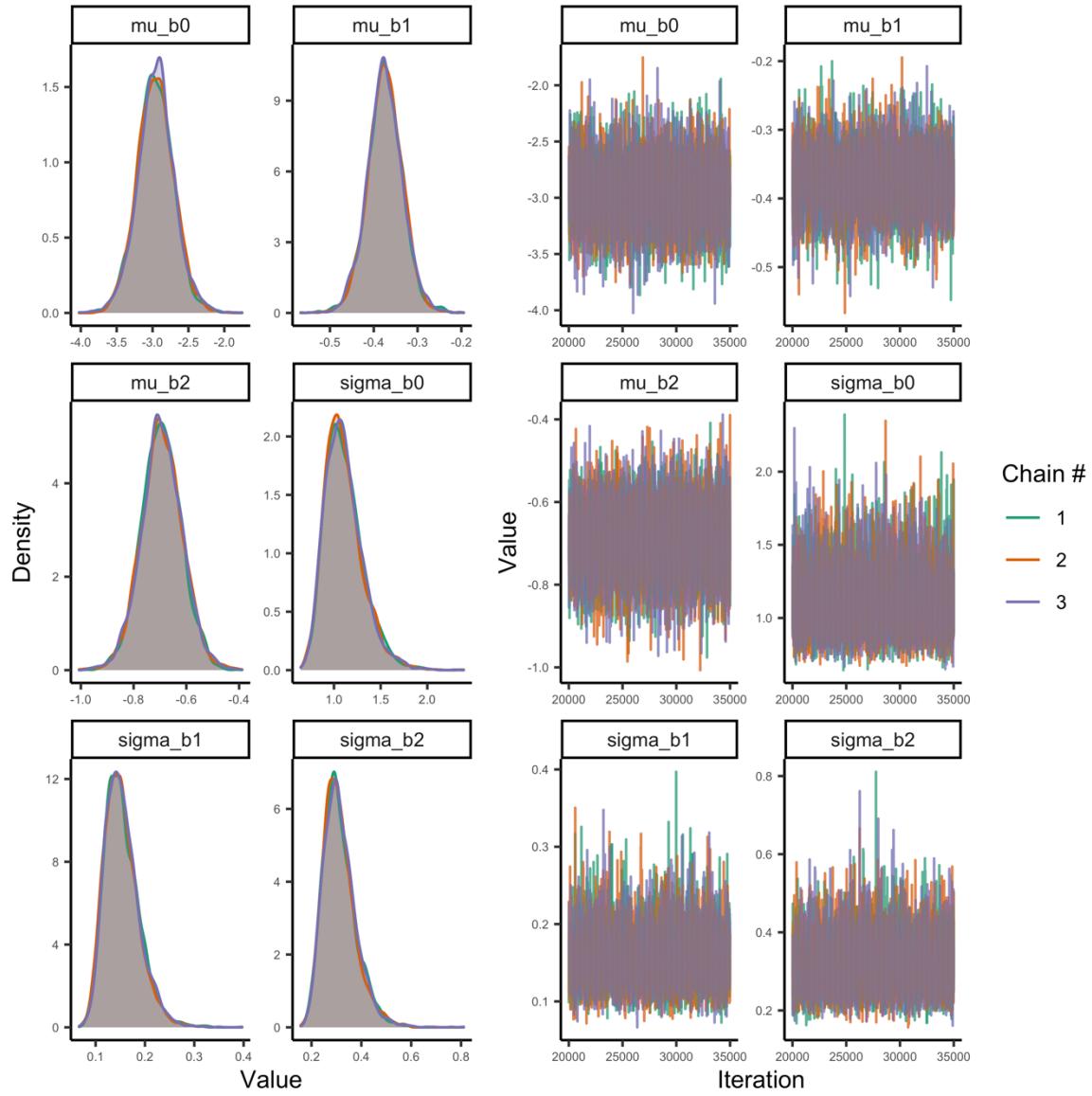
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306 **Model validation and fit**

307 Figures showing convergence of species-level parameters can be found on:

308 <https://github.com/maxlindmark/scaling>, in this section only global parameters are visualized.

309 **Maximum consumption rate – below peak temperatures**

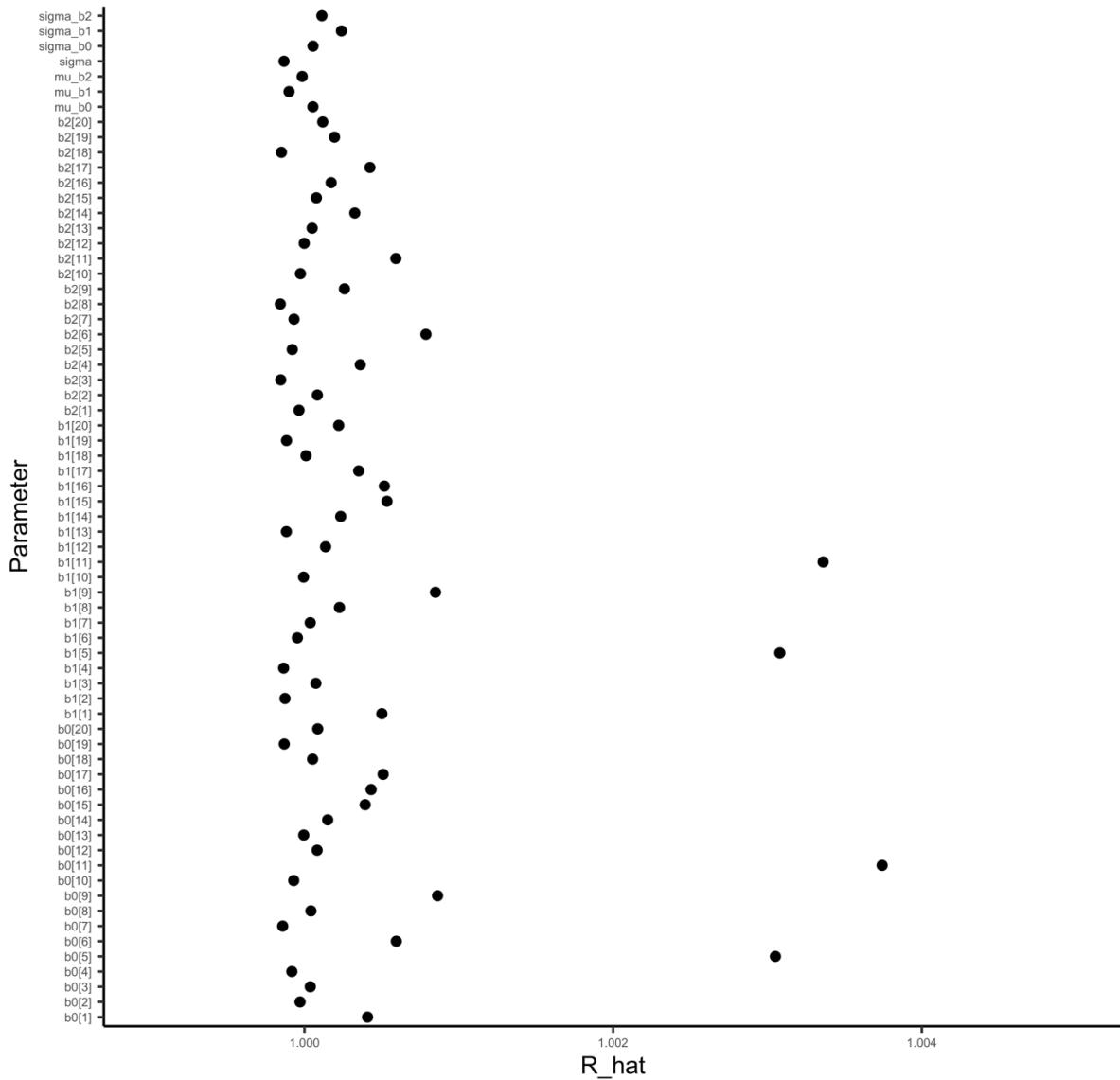


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311 *Fig. S8. Posterior densities and trace plots for evaluation of chain convergence (by chain,*  
312 *indicated by color), for the global-level parameters for the log-linear maximum consumption*  
313 *rate model at temperatures below peak temperatures.*

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### Potential Scale Reduction Factors



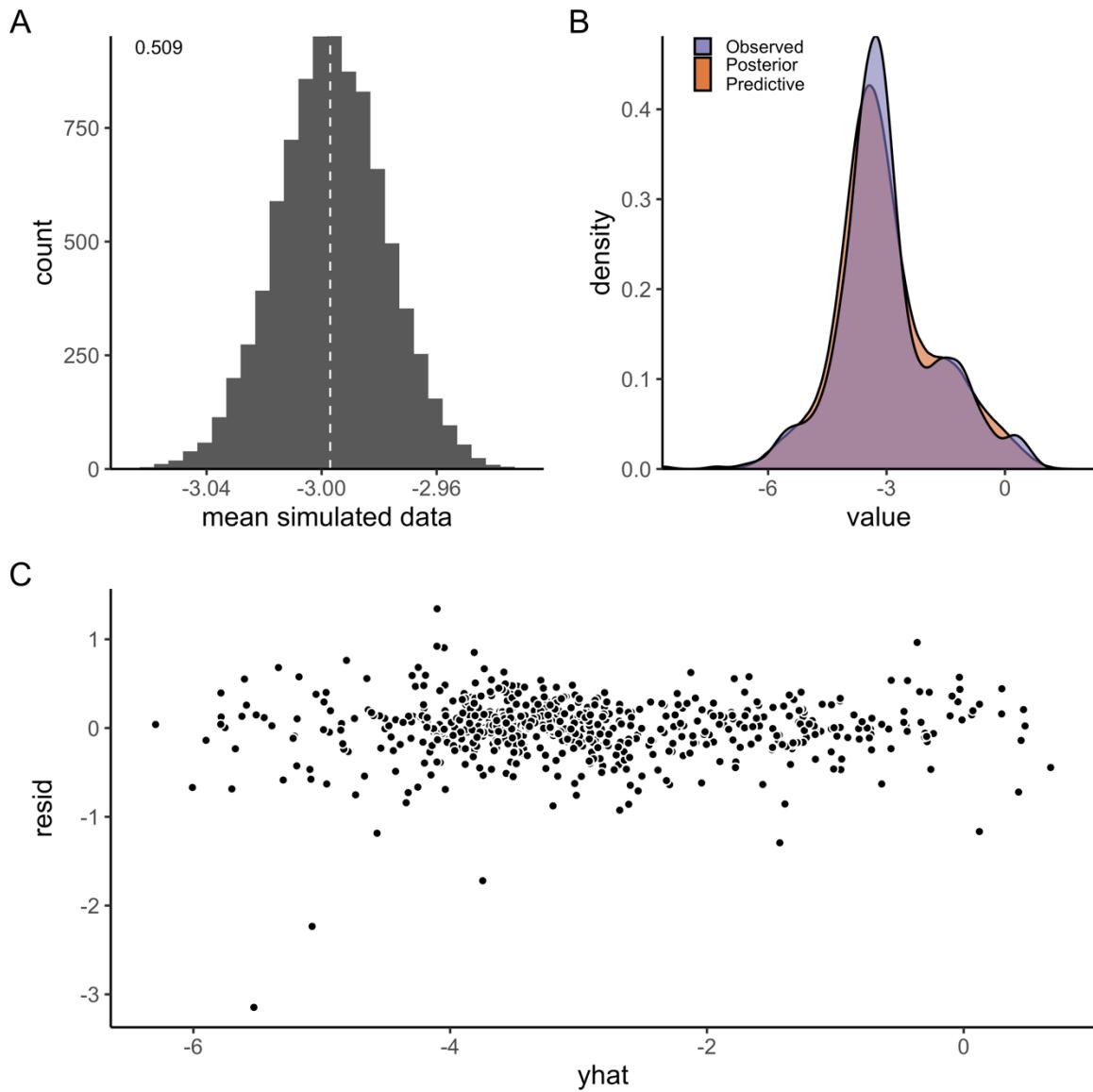
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316 *Fig. S9. Potential scale reduction factor ( $\hat{R}$ ) for the log-linear maximum consumption rate*  
 317 *model. This factor is based on the comparison of between and within-chain variation for the*  
 318 *same parameter. A value close to one implies chains converged to the same distribution. The*  
 319 *index of the parameter corresponds to species. The index of the parameter corresponds to*  
 320 *species in alphabetical order.*

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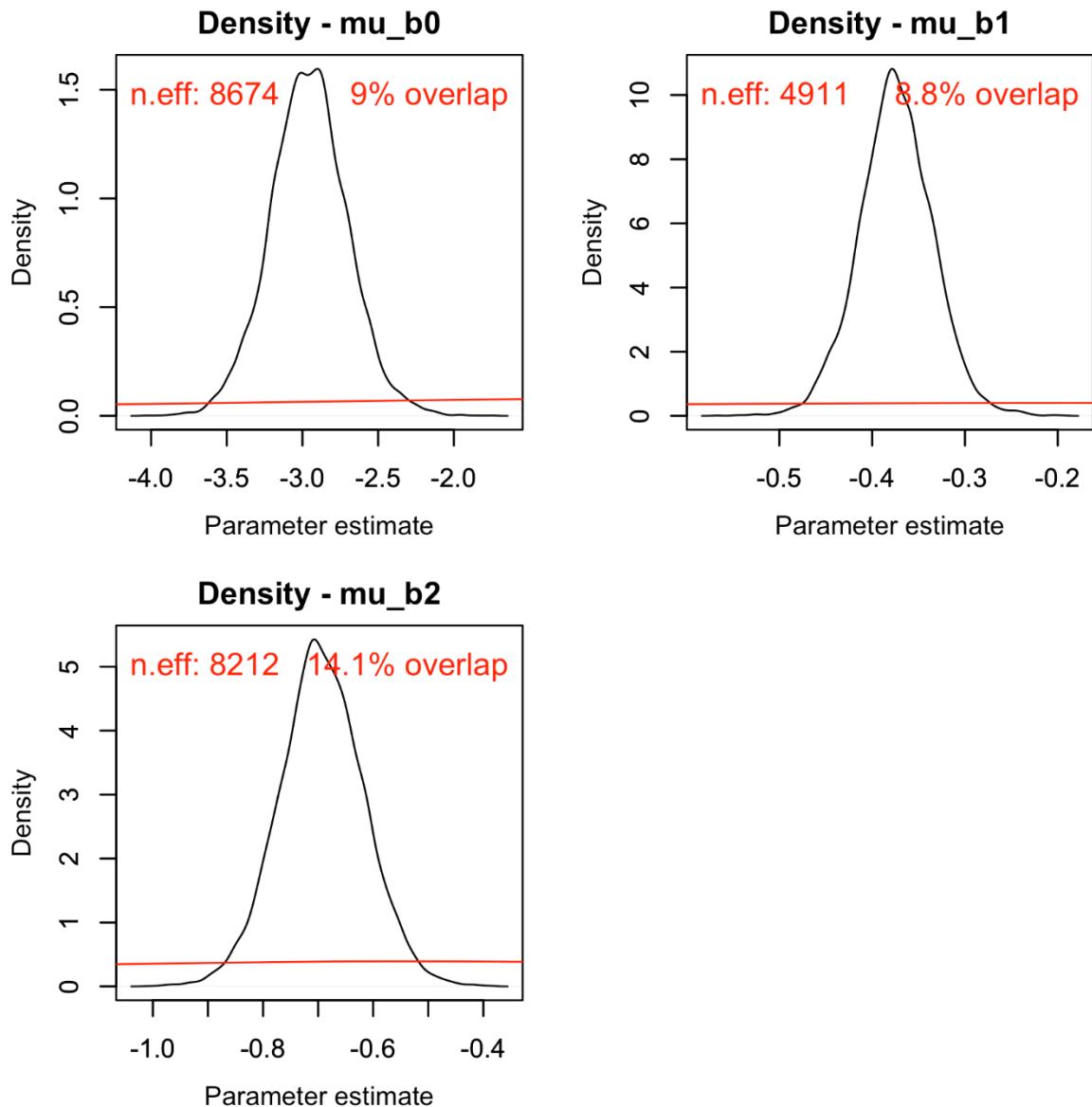
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325 *Fig. S10. A) Model fit (mean) for the log-linear model of maximum consumption rate at*  
 326 *temperatures below temperature peak (by species). Fit is evaluated by simulating data from*  
 327 *the likelihood (at each iteration of the MCMC chain), to compare how well it matches the*  
 328 *original data. Each simulated data point is assigned a 0 or 1 if it is below or above the mean*  
 329 *data point (the vertical line corresponds to the mean in data). The number in the plot*  
 330 *corresponds to the mean of the vector of 0's and 1's. B) Posterior predictive distribution*  
 331 *(orange) and distribution of data (purple). C) Difference between the observed value and the*  
 332 *posterior median of the predicted value, plotted against fitted value.*



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334 *Fig. S11. Posterior (black) and prior distribution (red) for the global parameters in the log-*  
 335 *linear model for maximum consumption rate, including their % overlap and effective sample*  
 336 *size (n.eff).*

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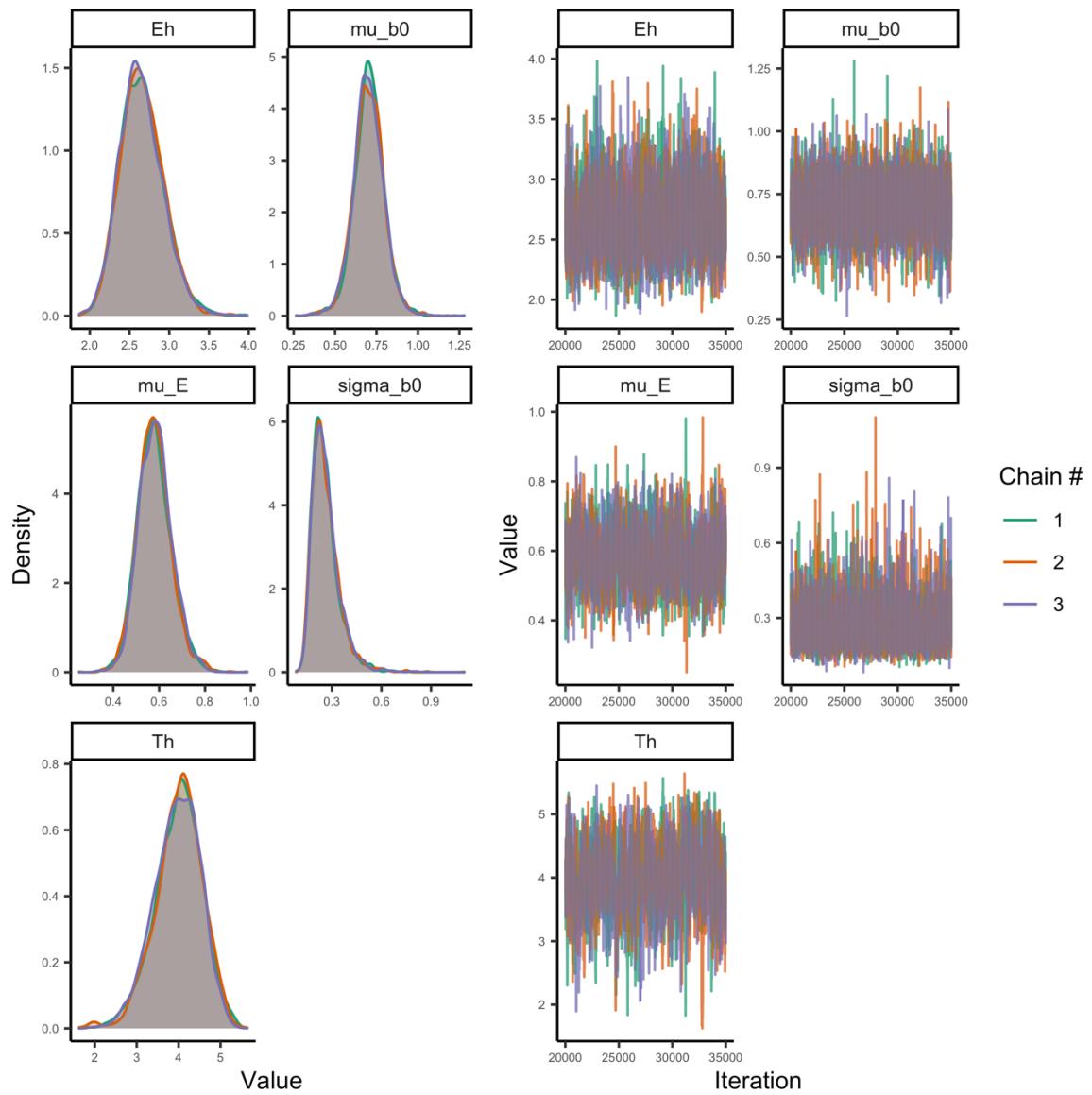
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342    **Maximum consumption rate – including beyond peak temperatures**



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344    Fig. S12. Posterior densities and trace plots for evaluation of chain convergence (by chain,  
 345    indicated by color), for the global-level parameters for the Sharpe-Schoolfield model fitted to  
 346    maximum consumption rate data with temperatures including beyond peak temperatures.

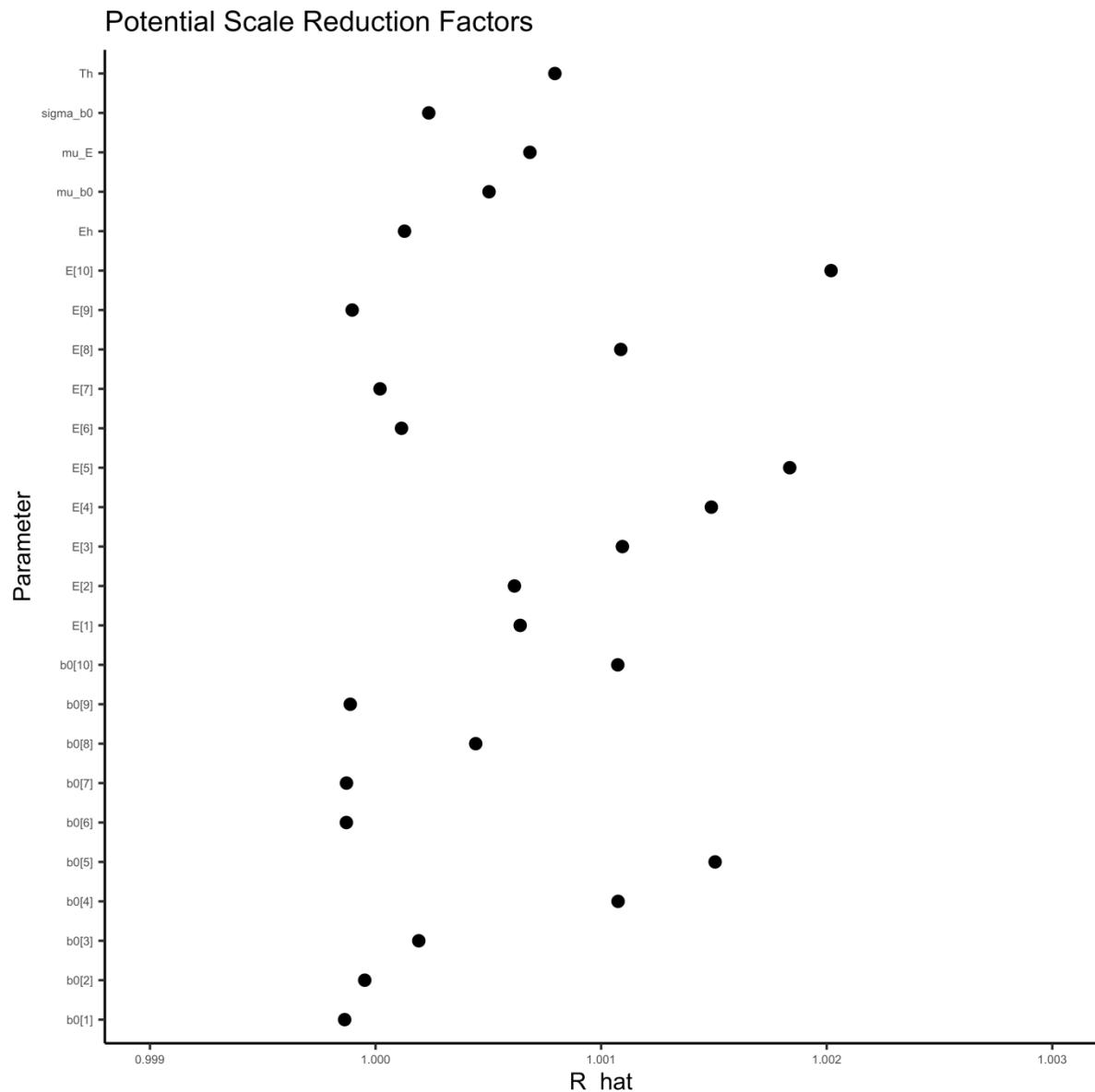
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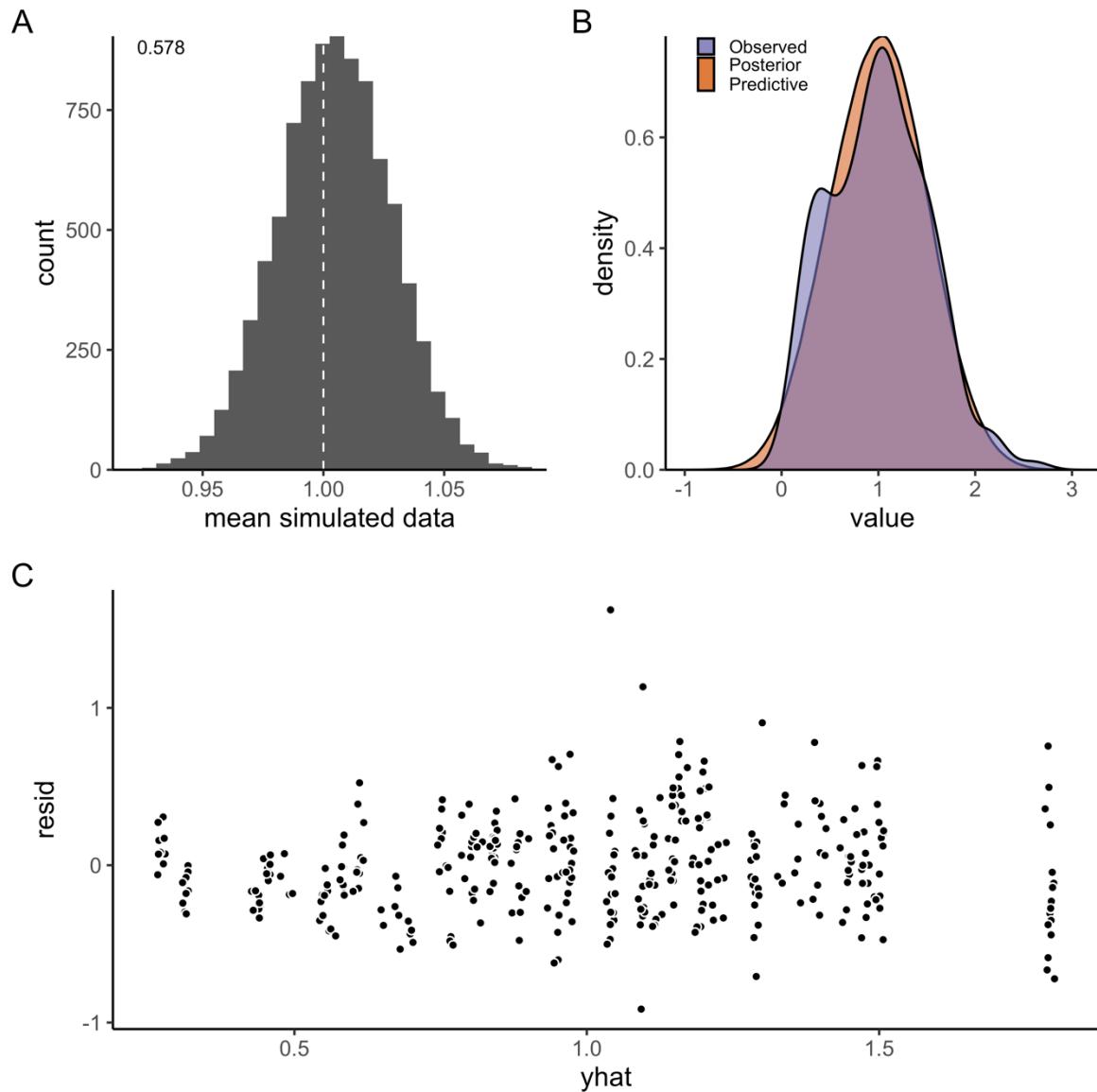
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353 *Fig. S13.* Potential scale reduction factor ( $\hat{R}$ ) for the Sharpe-Schoolfield model fitted to  
 354 maximum consumption rate data (including data beyond peak). This factor is based on the  
 355 comparison of between and within-chain variation for the same parameter. A value close to  
 356 one implies chains converged to the same distribution. The index of the parameter corresponds  
 357 to species in alphabetical order.

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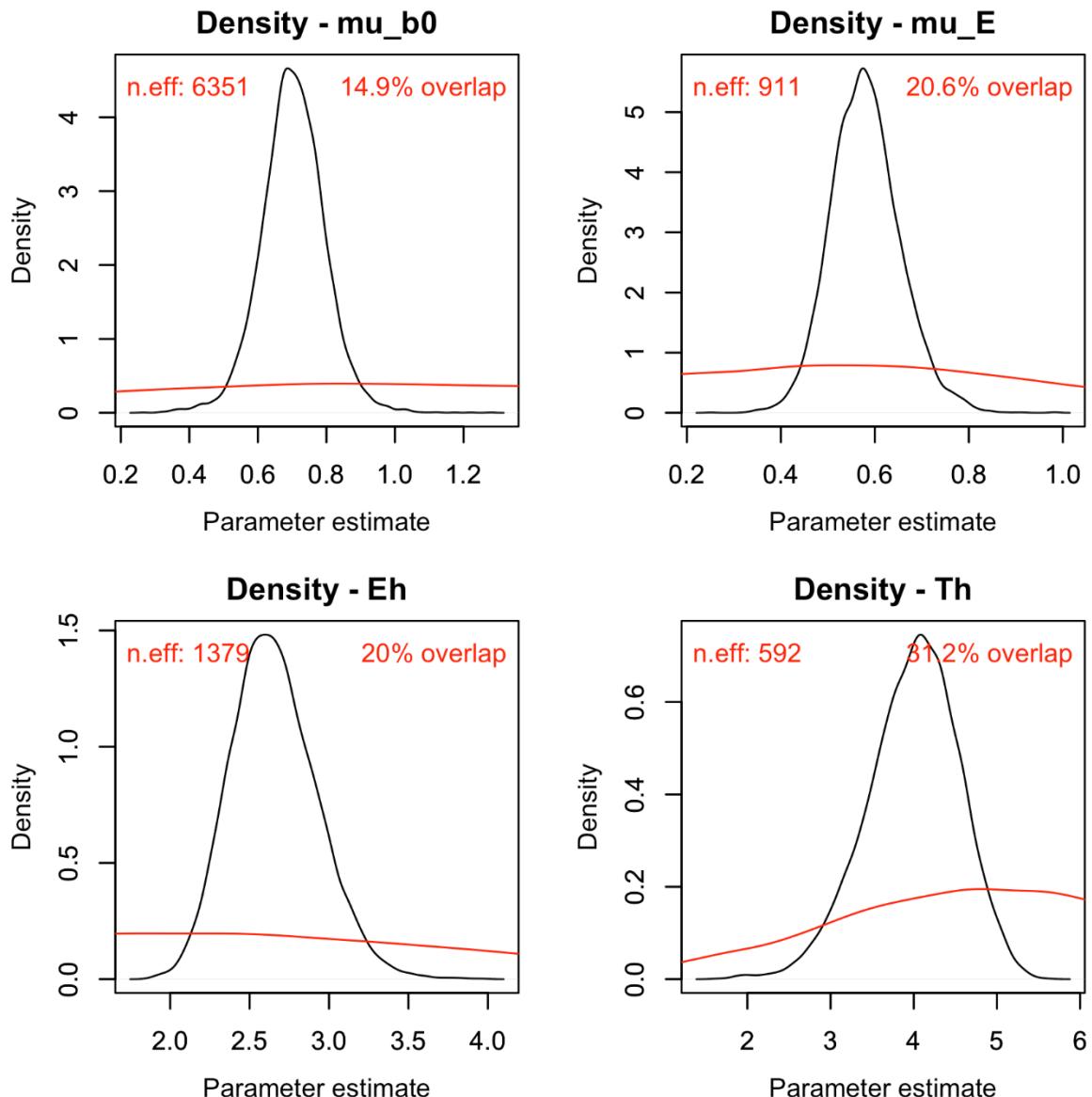
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362 *Fig. S14. A) Model fit (mean) for the Sharpe-Schoolfield model fitted to maximum consumption*  
 363 *rate data including temperatures beyond peak (by species). Fit is evaluated by simulating data*  
 364 *from the likelihood (at each iteration of the MCMC chain), to compare how well it matches the*  
 365 *original data. Each simulated data point is assigned a 0 or 1 if it is below or above the mean*  
 366 *data point (the vertical line corresponds to the mean in data). The number in the plot*  
 367 *corresponds to the mean of the vector of 0's and 1's. B) Posterior predictive distribution*  
 368 *(orange) and distribution of data (purple). C) Difference between the observed value and the*  
 369 *posterior median of the predicted value, plotted against fitted value.*



370

371 *Fig. S15. Posterior (black) and prior distribution (red) for the global parameters in the Sharpe-*  
 372 *Schoolfield model for maximum consumption rate including data beyond peak, including their*  
 373 *% overlap (rounded) and effective sample size (n.eff).*

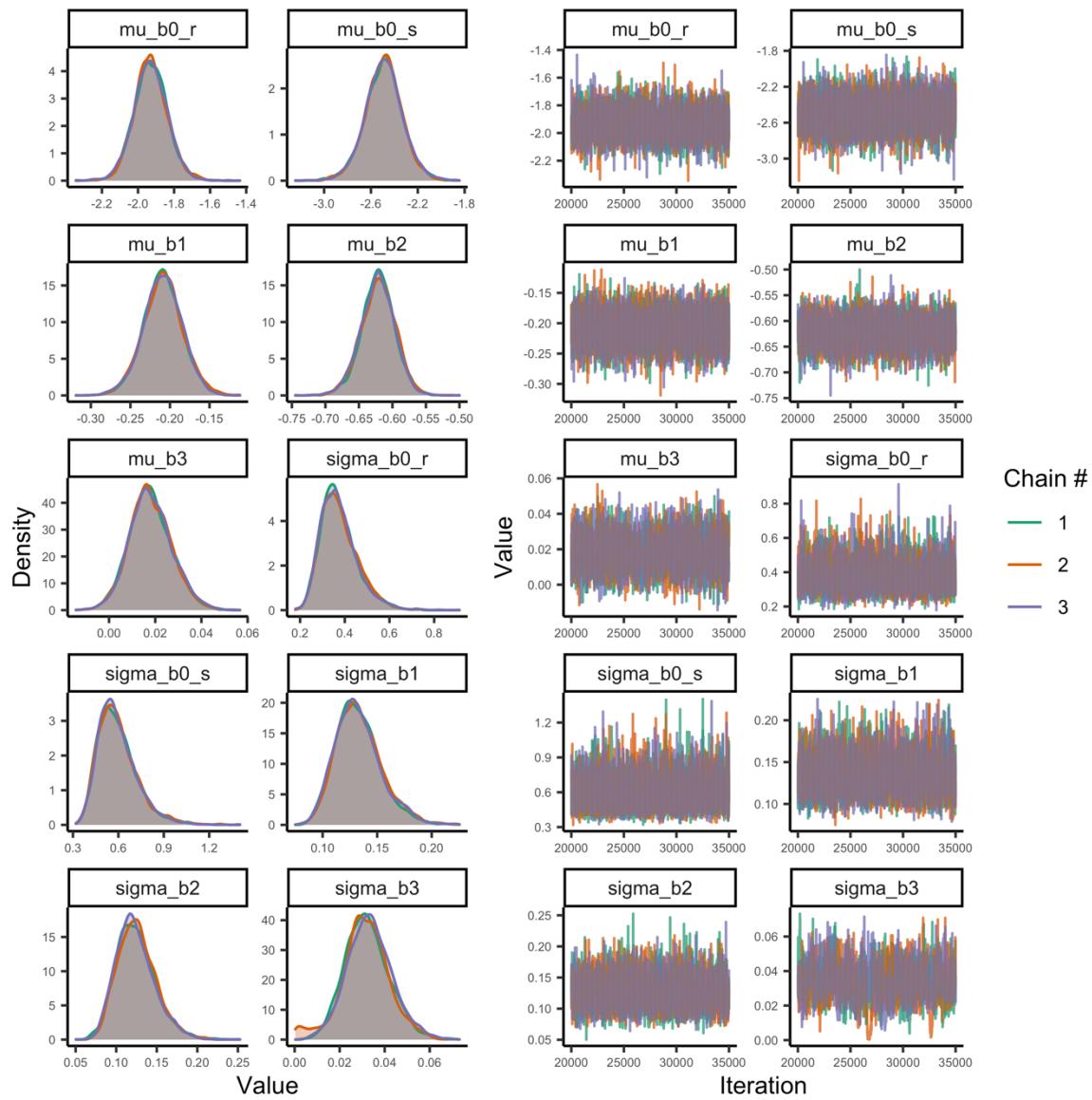
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379 **Metabolic rate**

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381 *Fig. S16. Posterior densities and trace plots for evaluation of chain convergence (by chain,  
 382 indicated by color), for the global-level parameters for the metabolic rate model at  
 383 temperatures below peak temperatures.*

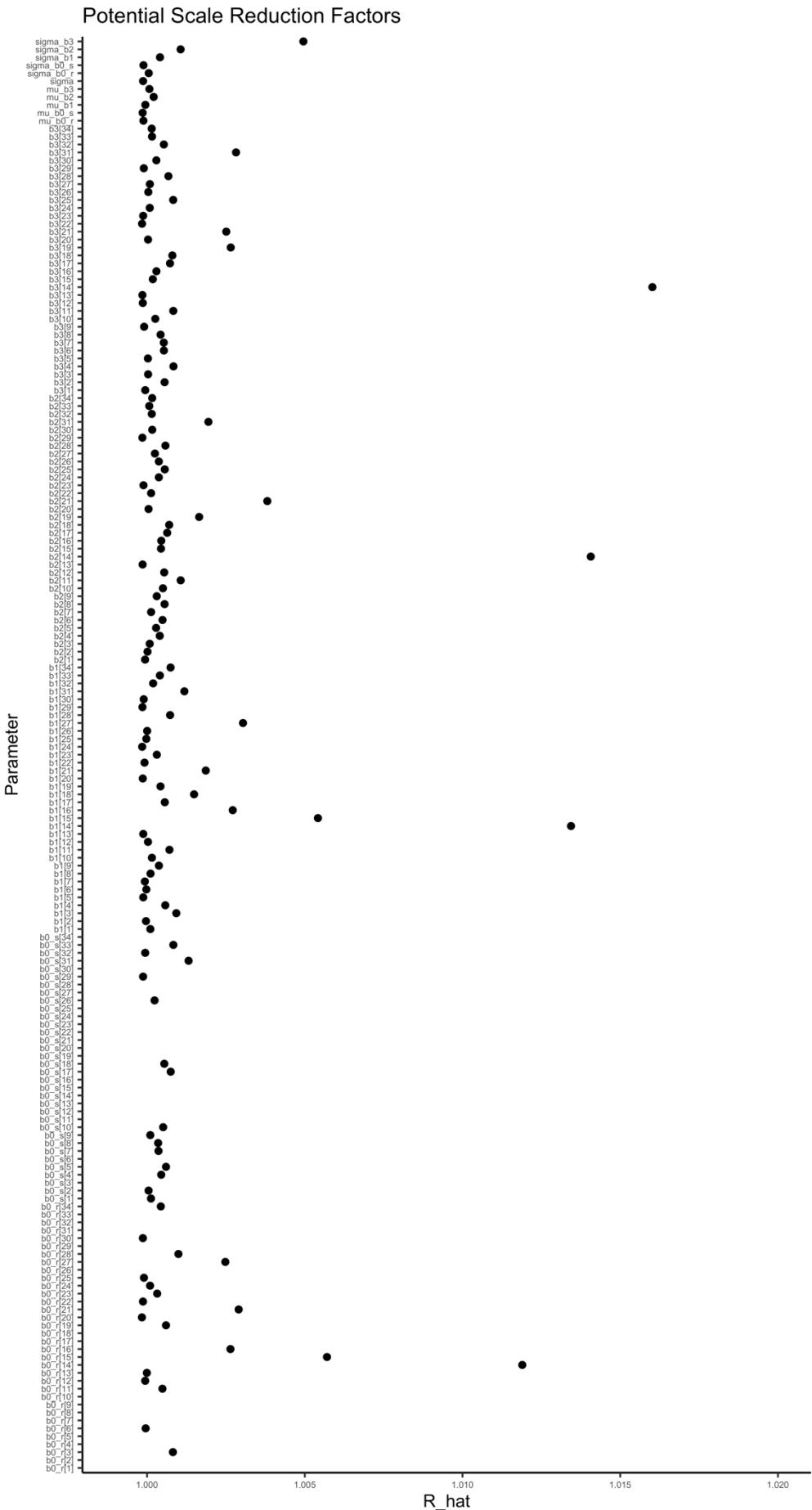
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390 *Fig. S17. Potential scale reduction factor ( $\hat{R}$ ) for the metabolic rate model. This factor is based*  
391 *on the comparison of between and within-chain variation for the same parameter. A value close*  
392 *to one implies chains converged to the same distribution. The index of the parameter*  
393 *corresponds to species in alphabetical order.*

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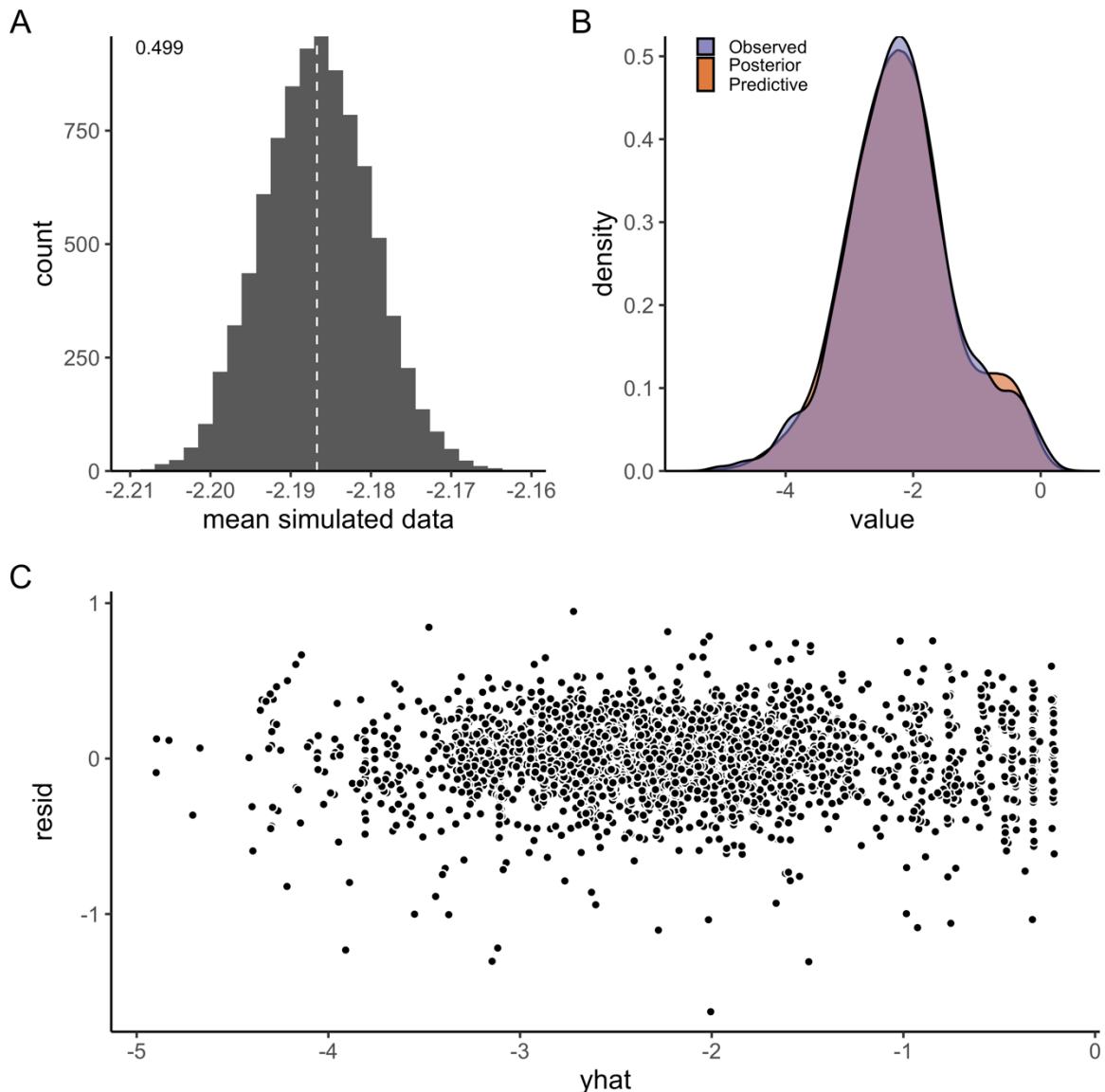
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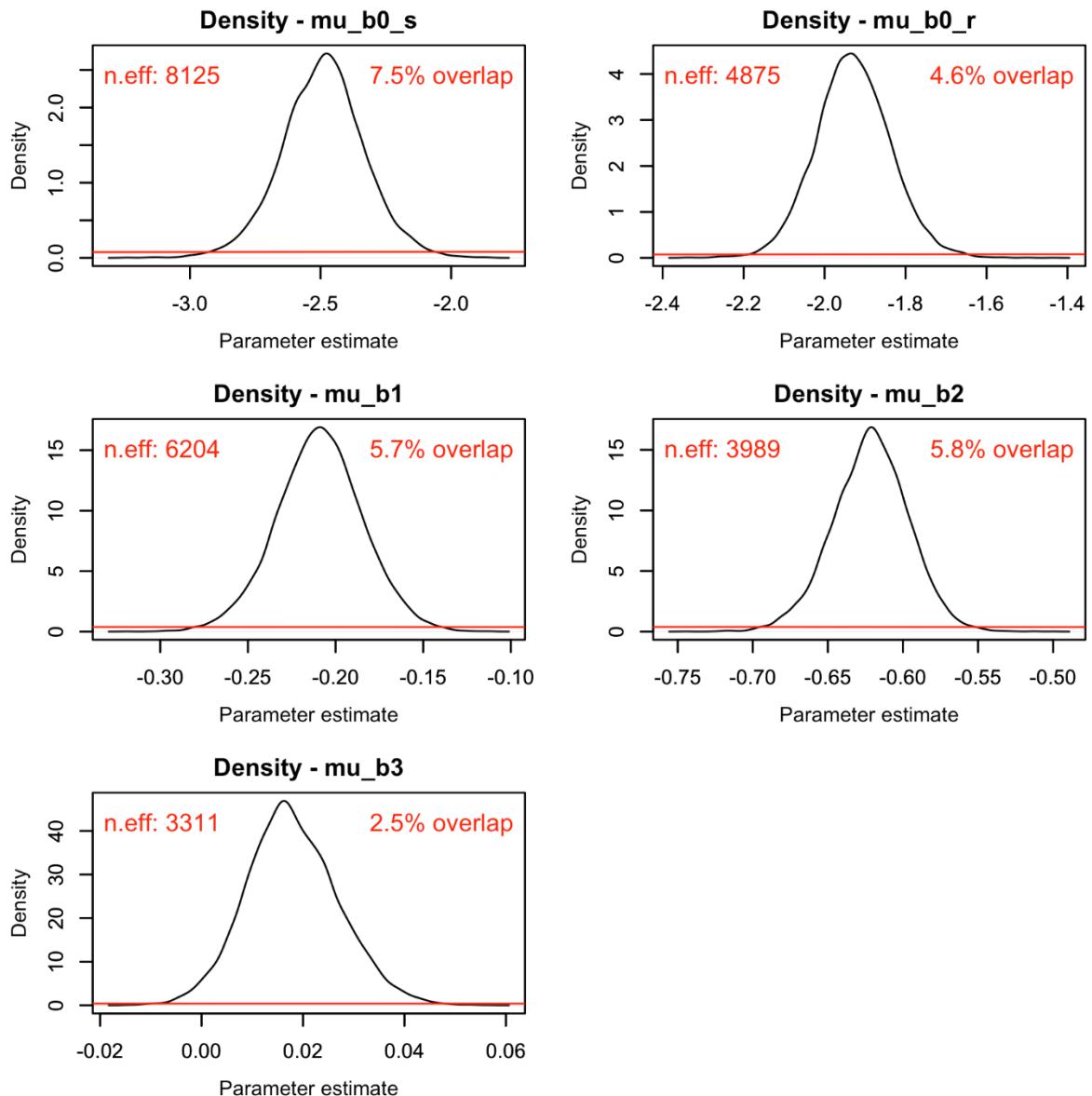
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416 *Fig. S18. A) Model fit (mean) for the log-linear model of metabolic rate. Fit is evaluated by*  
 417 *simulating data from the likelihood (at each iteration of the MCMC chain), to compare how*  
 418 *well it matches the original data. Each simulated data point is assigned a 0 or 1 if it is below*  
 419 *or above the mean data point (the vertical line corresponds to the mean in data). The number*  
 420 *in the plot corresponds to the mean of the vector of 0's and 1's. B) Posterior predictive*  
 421 *distribution (orange) and distribution of data (purple). C) Difference between the observed*  
 422 *value and the posterior median of the predicted value, plotted against fitted value.*

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425 *Fig. S19. Posterior (black) and prior distribution (red) for the global parameters in the model*  
 426 *for metabolic rate, including their % overlap and effective sample size (n.eff).*

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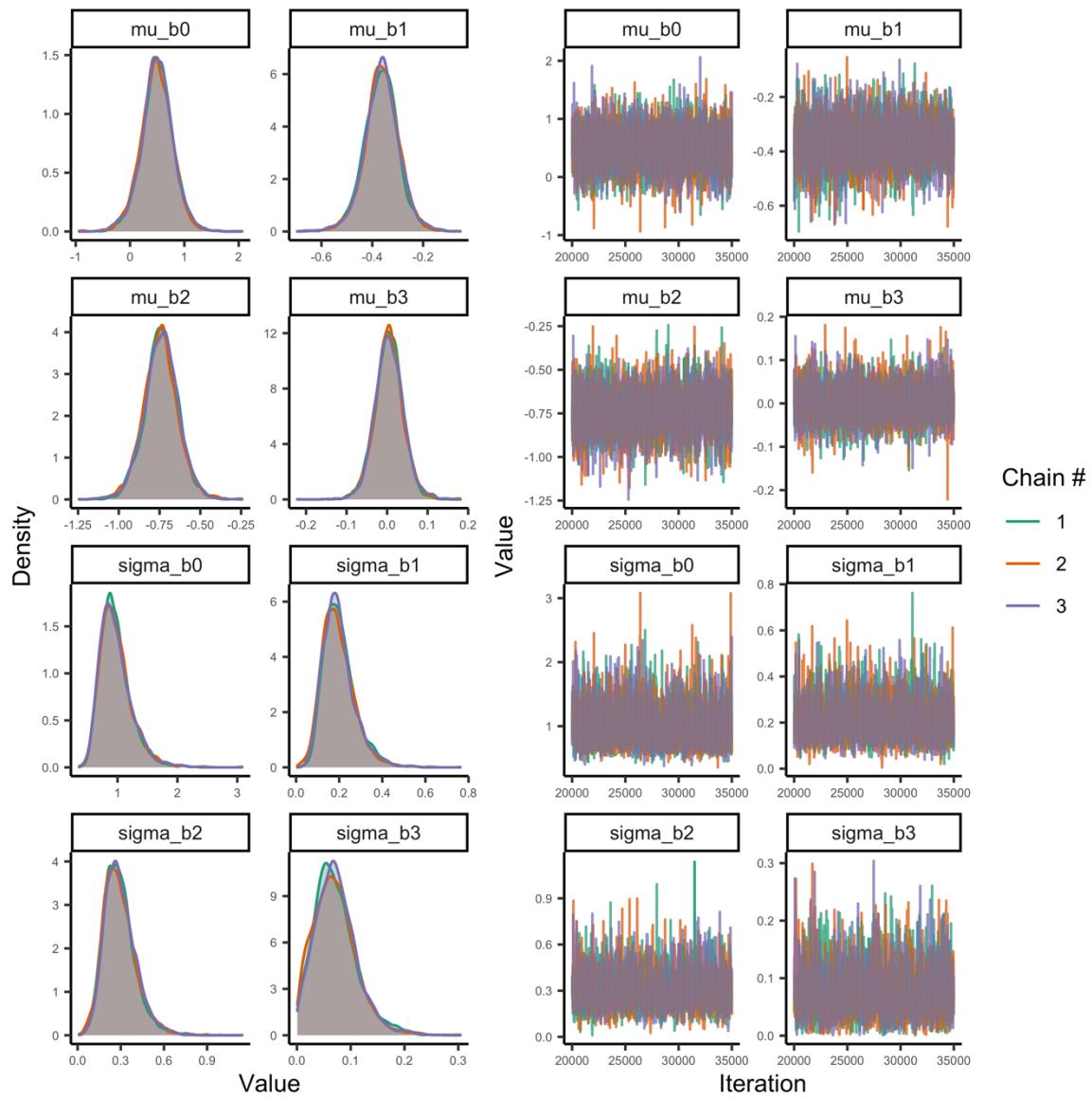
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433 **Growth rate**



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435 *Fig. S20. Posterior densities and trace plots for evaluation of chain convergence (by chain,  
436 indicated by color), for the global-level parameters for the growth rate model at temperatures  
437 below optimum temperatures.*

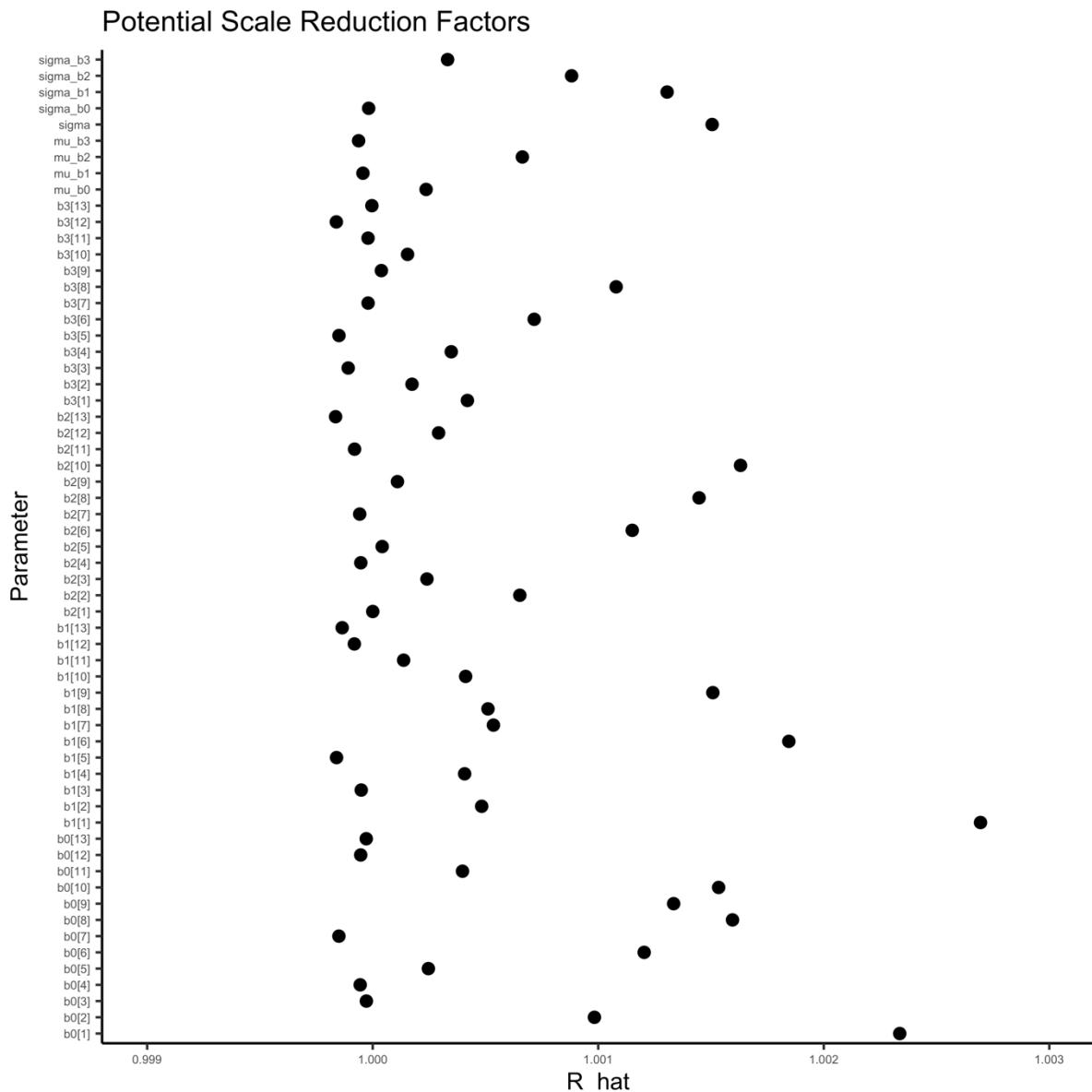
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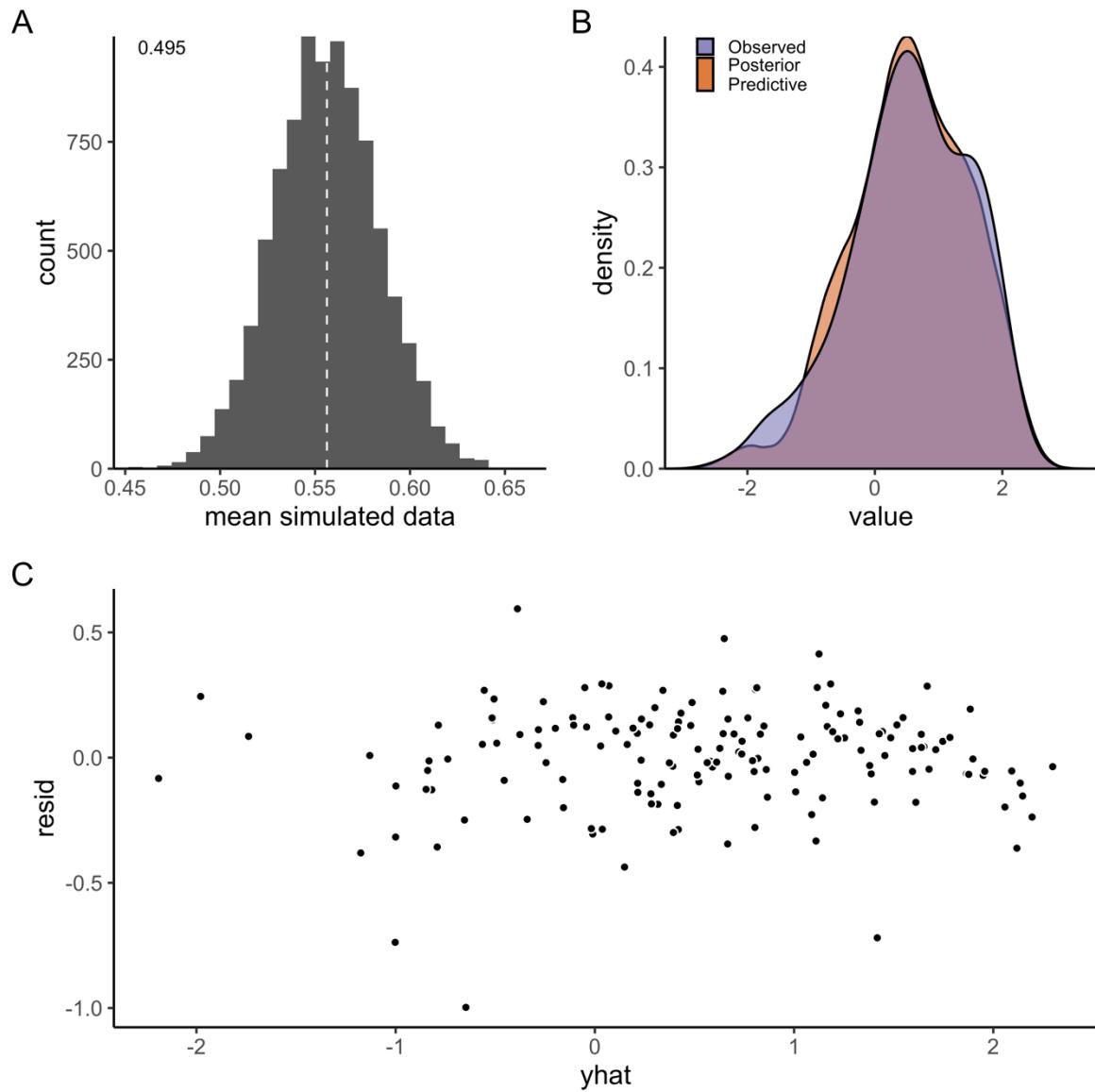
444 *Fig. S21. Potential scale reduction factor ( $\hat{R}$ ) for the growth rate model. This factor is based  
445 on the comparison of between and within-chain variation for the same parameter. A value close  
446 to one implies chains converged to the same distribution. The index of the parameter  
447 corresponds to species in alphabetical order.*

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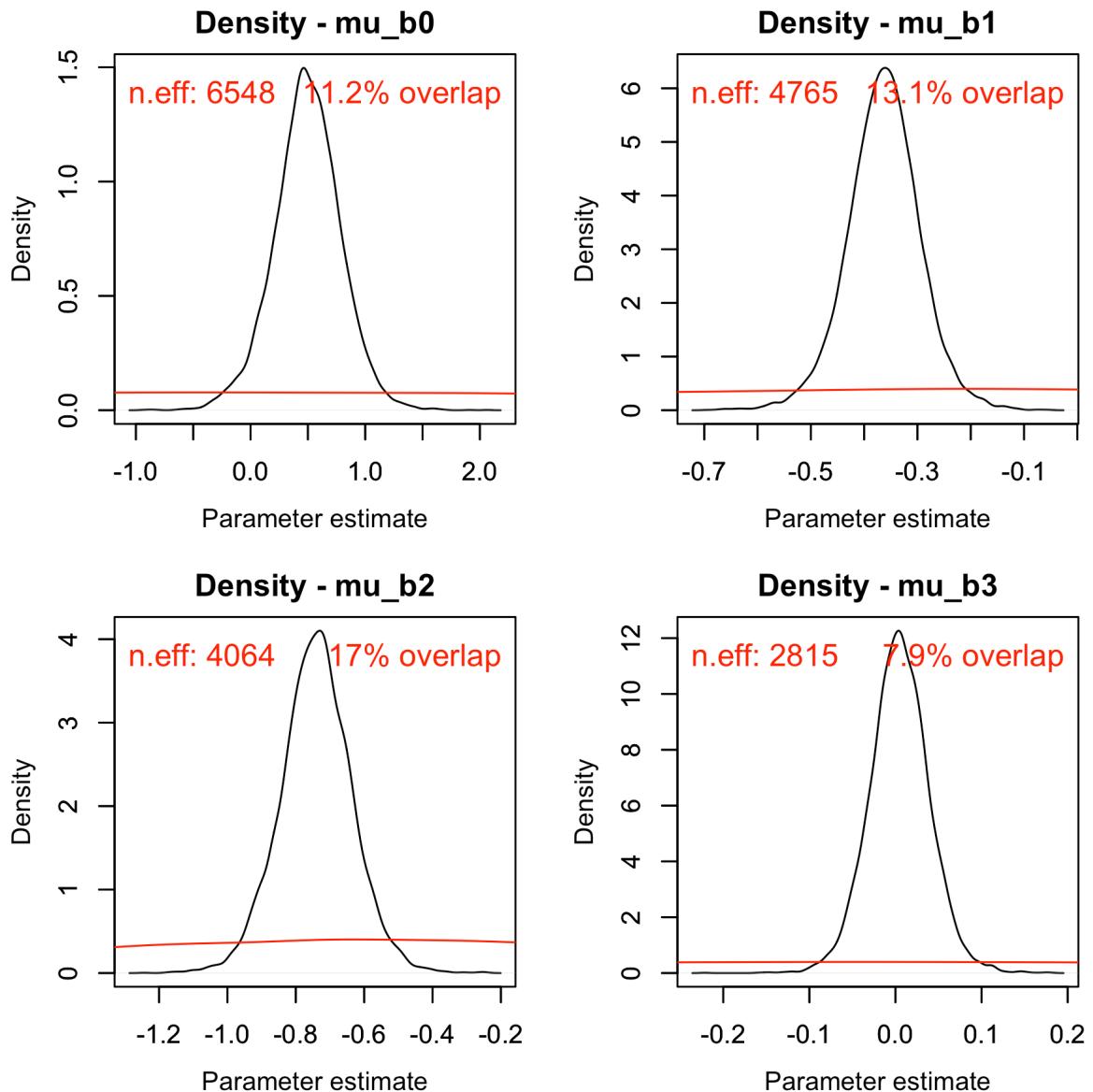
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453 *Fig. S22. A) Model fit (mean) for the model of growth at temperatures below temperature*  
 454 *optimum (by species). Fit is evaluated by simulating data from the likelihood (at each iteration*  
 455 *of the MCMC chain), to compare how well it matches the original data. Each simulated data*  
 456 *point is assigned a 0 or 1 if it is below or above the mean data point (the vertical line*  
 457 *corresponds to the mean in data). The number in the plot corresponds to the mean of the vector*  
 458 *of 0's and 1's. B) Posterior predictive distribution (orange) and distribution of data (purple).*  
 459 *C) Difference between the observed value and the posterior median of the predicted value,*  
 460 *plotted against fitted value.*



461

462 *Fig. S23. Posterior (black) and prior distribution (red) for the global parameters in the model*  
 463 *for growth rate, including their % overlap and effective sample size (n.eff).*

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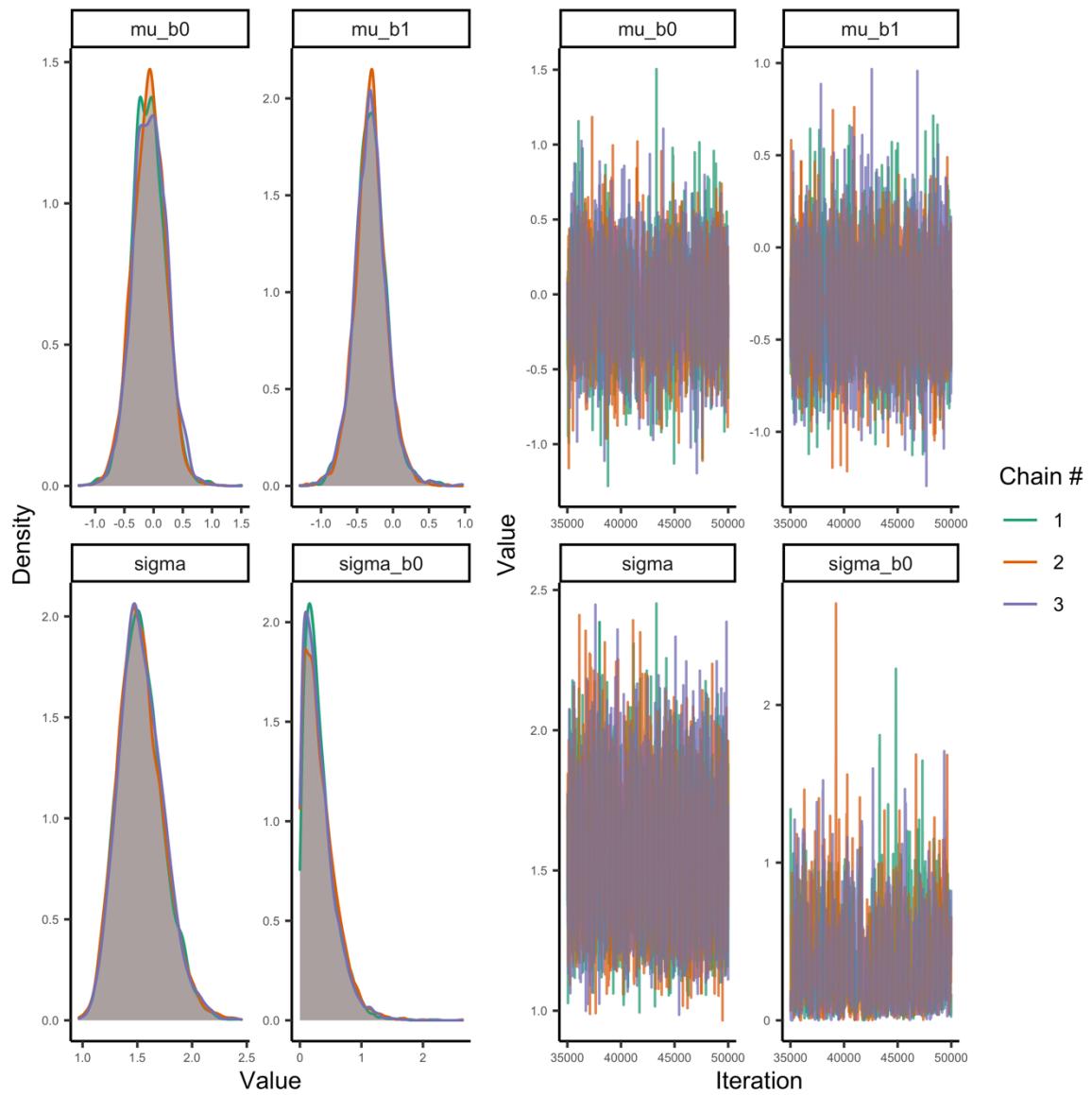
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470    ***Optimum growth temperature***



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472    *Fig. S24. Posterior densities and trace plots for evaluation of chain convergence (by chain,  
473 indicated by color), for the global-level parameters for the  $T_{opt}$  model.*

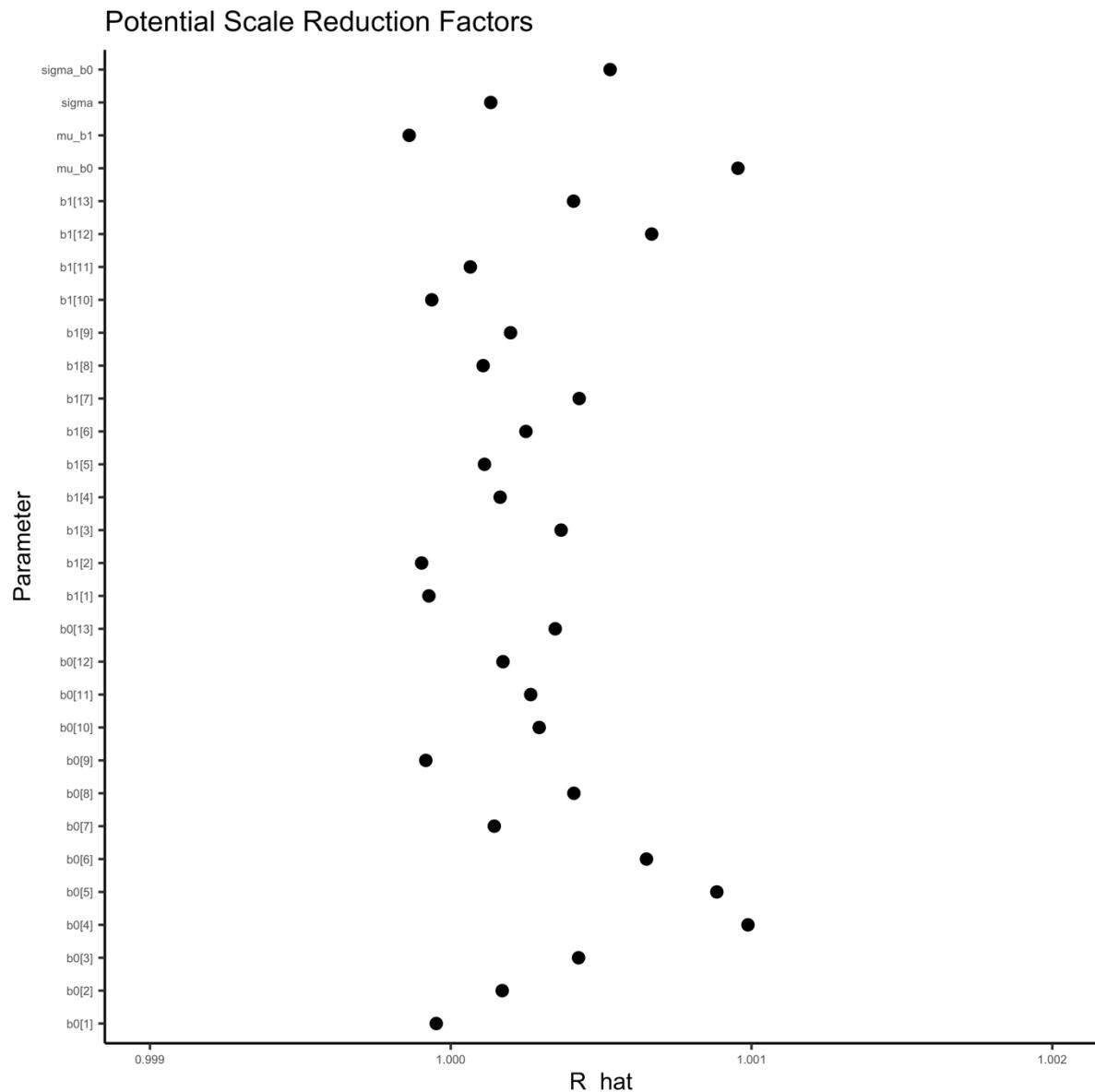
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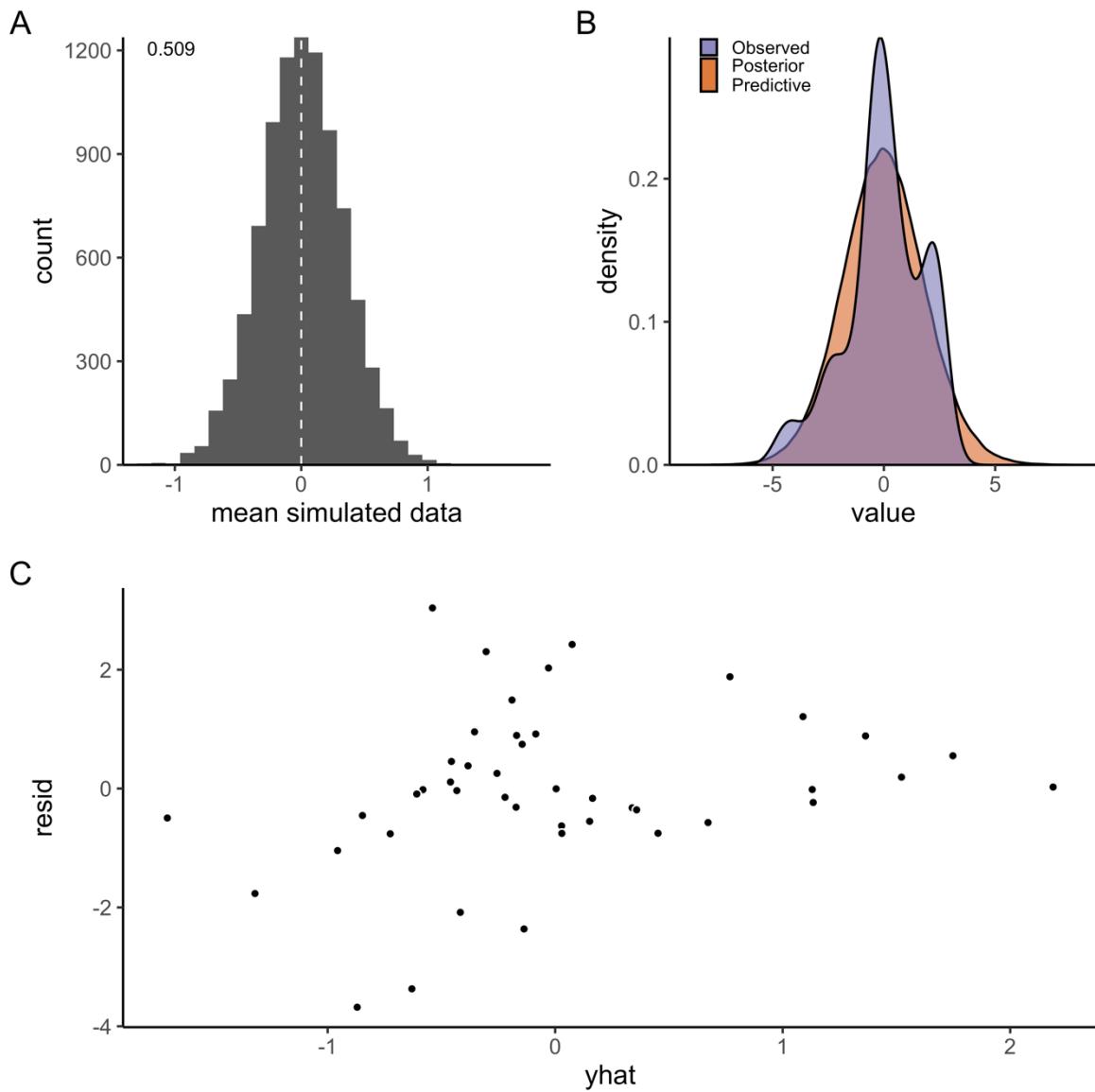
480    Fig. S25. Potential scale reduction factor ( $\hat{R}$ ) for the  $T_{opt}$  model. This factor is based on the  
 481    comparison of between and within-chain variation for the same parameter. A value close to  
 482    one implies chains converged to the same distribution. The index of the parameter corresponds  
 483    to species in alphabetical order.

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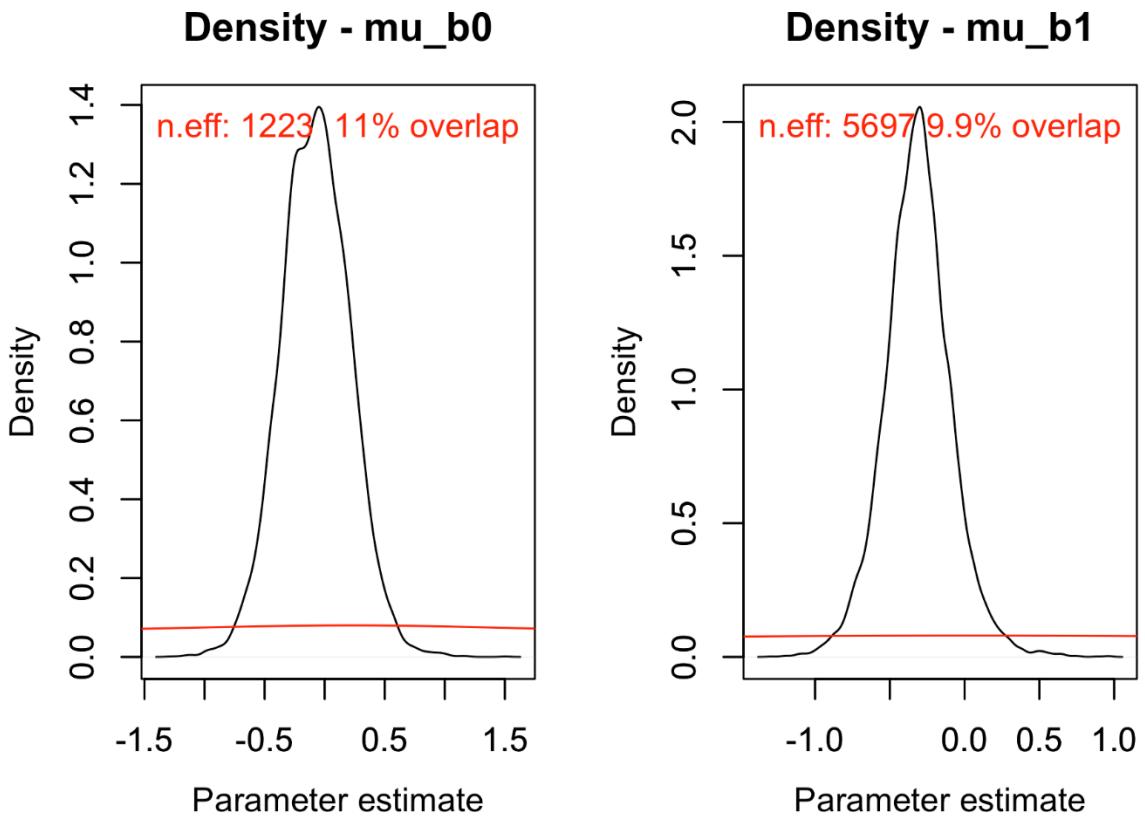
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489 Fig. S26. A) Model fit (mean) for the model of optimum growth temperature as a function of  
 490 body mass. Fit is evaluated by simulating data from the likelihood (at each iteration of the  
 491 MCMC chain), to compare how well it matches the original data. Each simulated data point is  
 492 assigned a 0 or 1 if it is below or above the mean data point (the vertical line corresponds to  
 493 the mean in data). The number in the plot corresponds to the mean of the vector of 0's and 1's.  
 494 B) Posterior predictive distribution (orange) and distribution of data (purple). C) Difference  
 495 between the observed value and the posterior median of the predicted value, plotted against  
 496 fitted value.



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Parameter estimate

Parameter estimate

498 *Fig. S27. Posterior (black) and prior distribution (red) for the global parameters in the model  
499 for  $T_{opt}$ , including their % overlap and effective sample size (n.eff).*

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