LifeWatch ERIC Thematic Service Workshop Ecological Responses to Climate Change: Implications on Human Well-being

21 February | 14.00 - 19.00
22 February | 09.30 - 13.00
Sala Conferenze - Rettorato Piazza Tancredi, 1 - Lecce, Italy

Individual metabolic responses to climate warming depend on biological and ecological context

LifeWatch ERIC

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UNIVERSITÀ DEL SALENTO

JUNIATA COLLEGE

Why study rate of metabolism?

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Energizes all biological processes

Useful indicator of the ‘pace of life’ that potentially affects the ecological success and evolutionary fitness of species.

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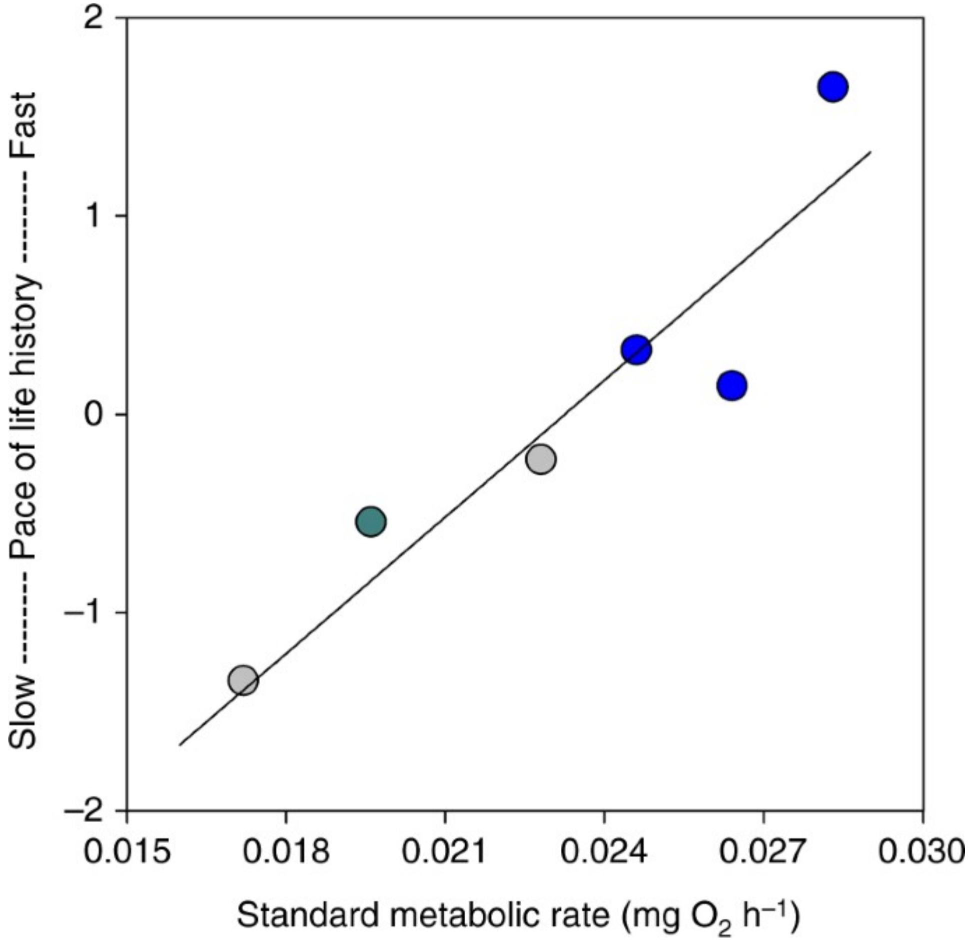

(Auer et al. 2018, Nat. Comm.)

What are the major factors affecting metabolic rate?

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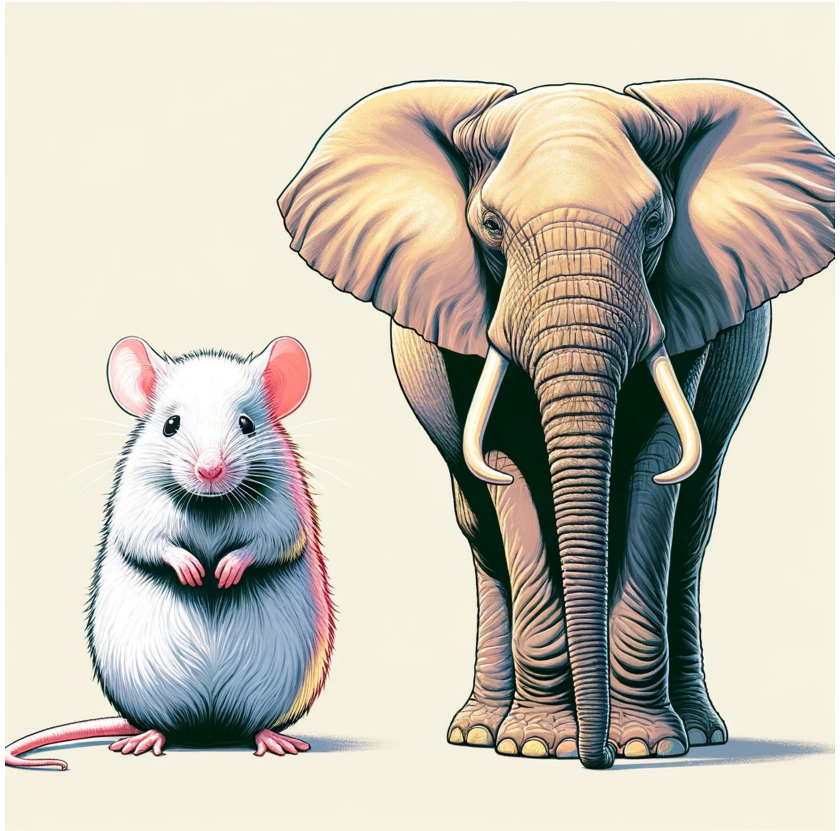
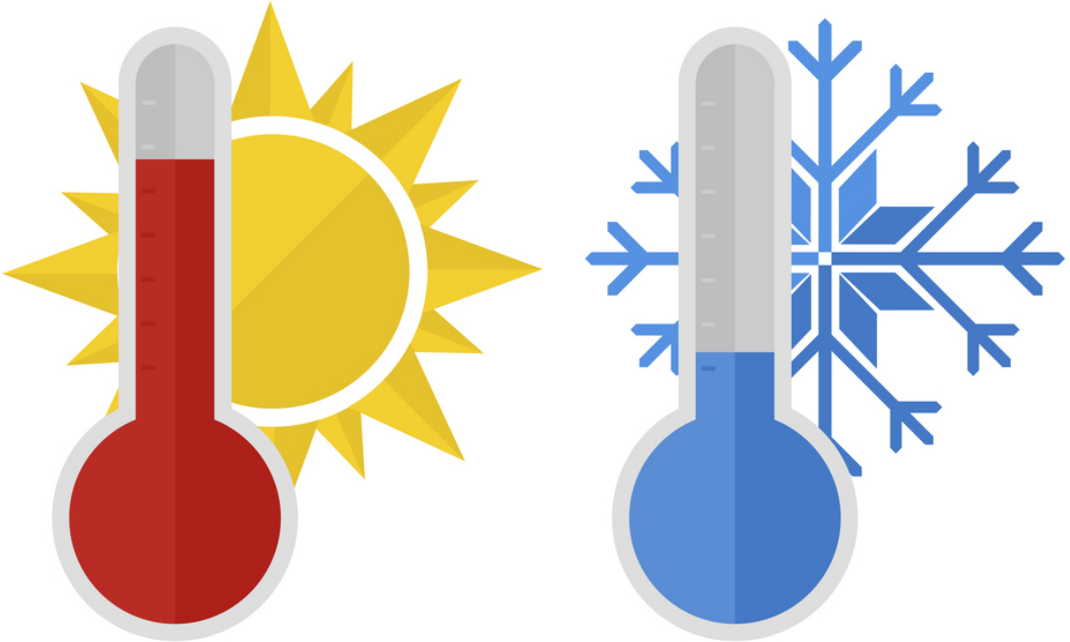
Body size

Temperature

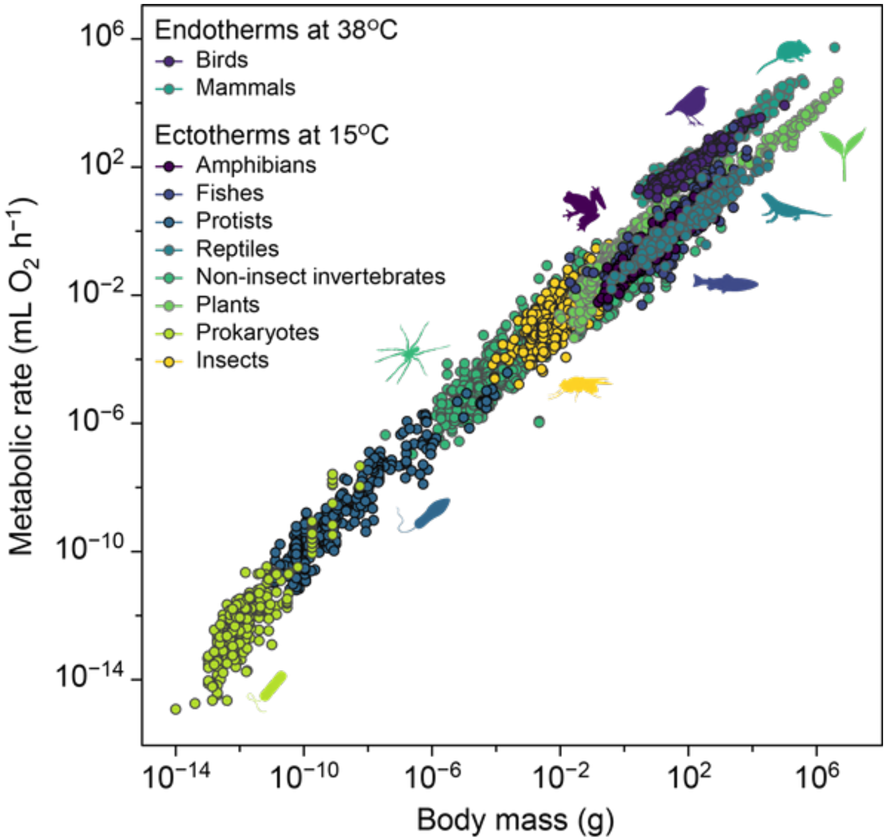




(Brown et al. 2004, Ecology; Glazier & Gjoni 2024, PTRS)

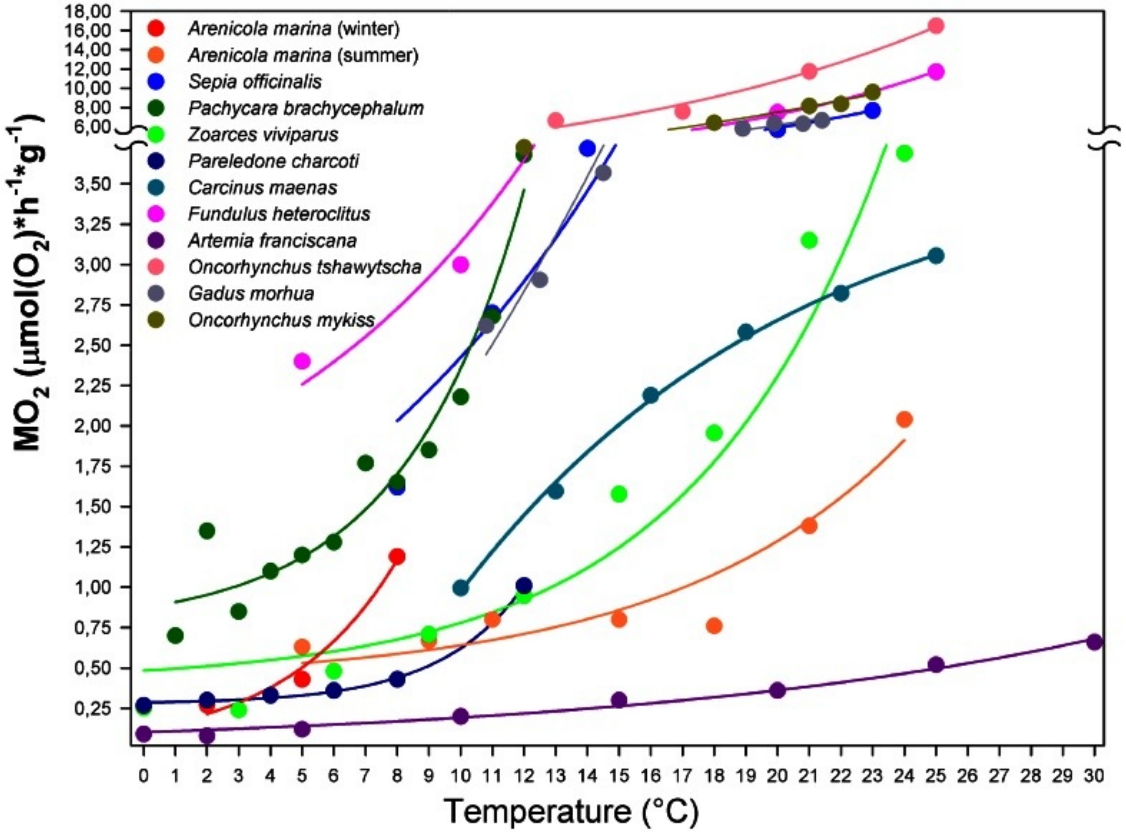
What are the major factors affecting metabolic rate?

Body size



(https://www.sebiology.org/events/animal-satellite-2022.html)

Temperature

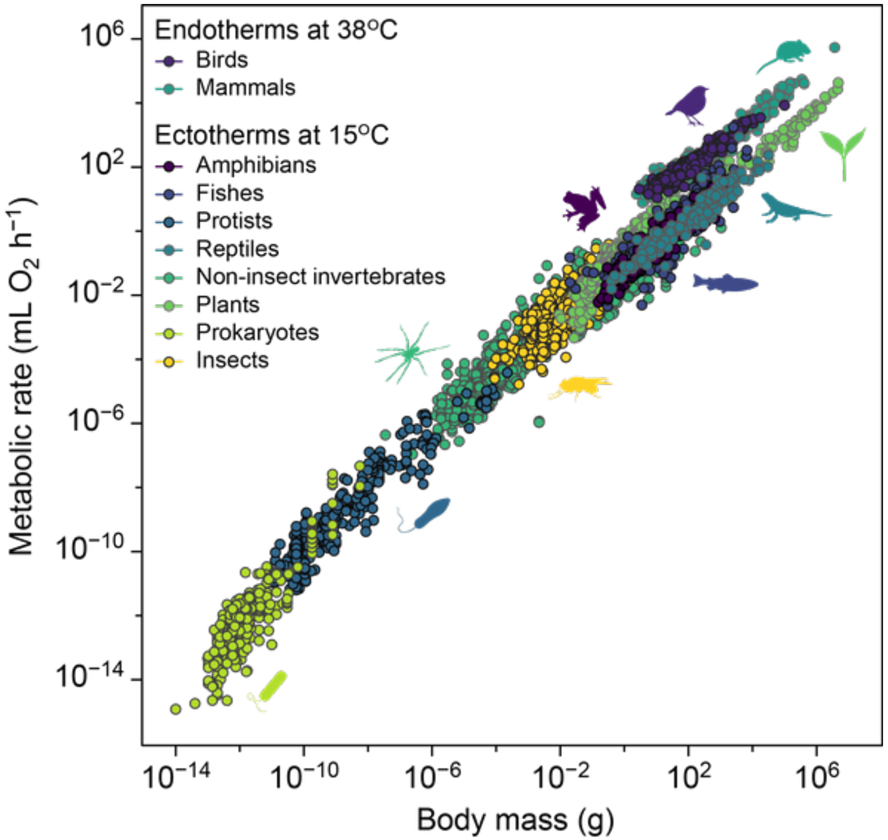


(https://www.quora.com/Why-does-oxygen-consumption-increase-with-temperature)

What are the major factors affecting metabolic rate?

Decrease at high T

Body size



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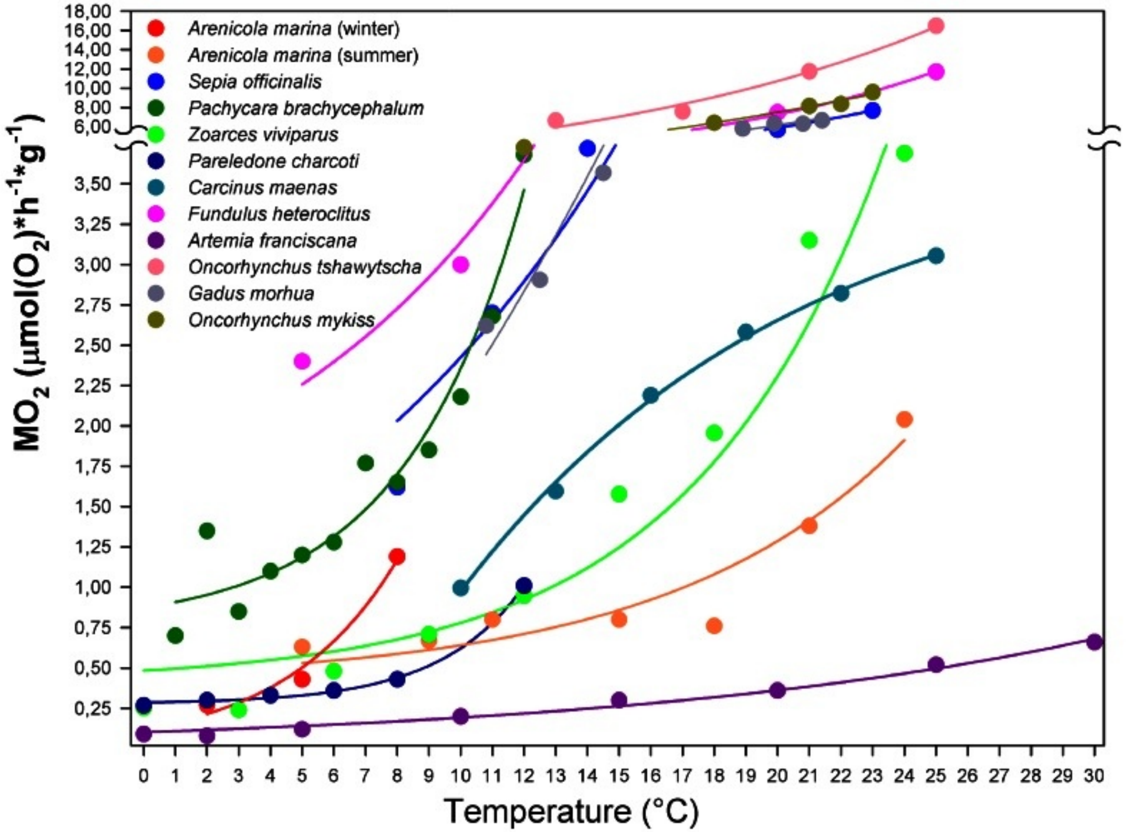
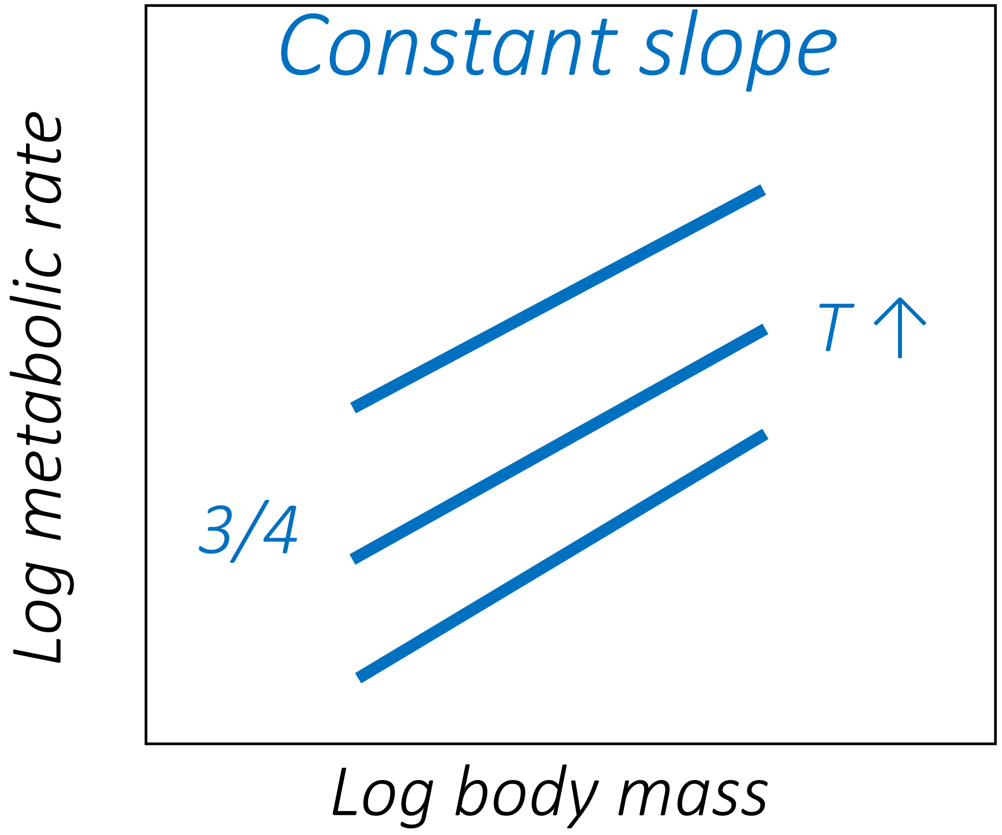


(Unimodal curves: Michaletz & Garen 2024, Ecol. Lett.)

(https://www.quora.com/Why-does-oxygen-consumption-increase-with-temperature)

Theoretical background

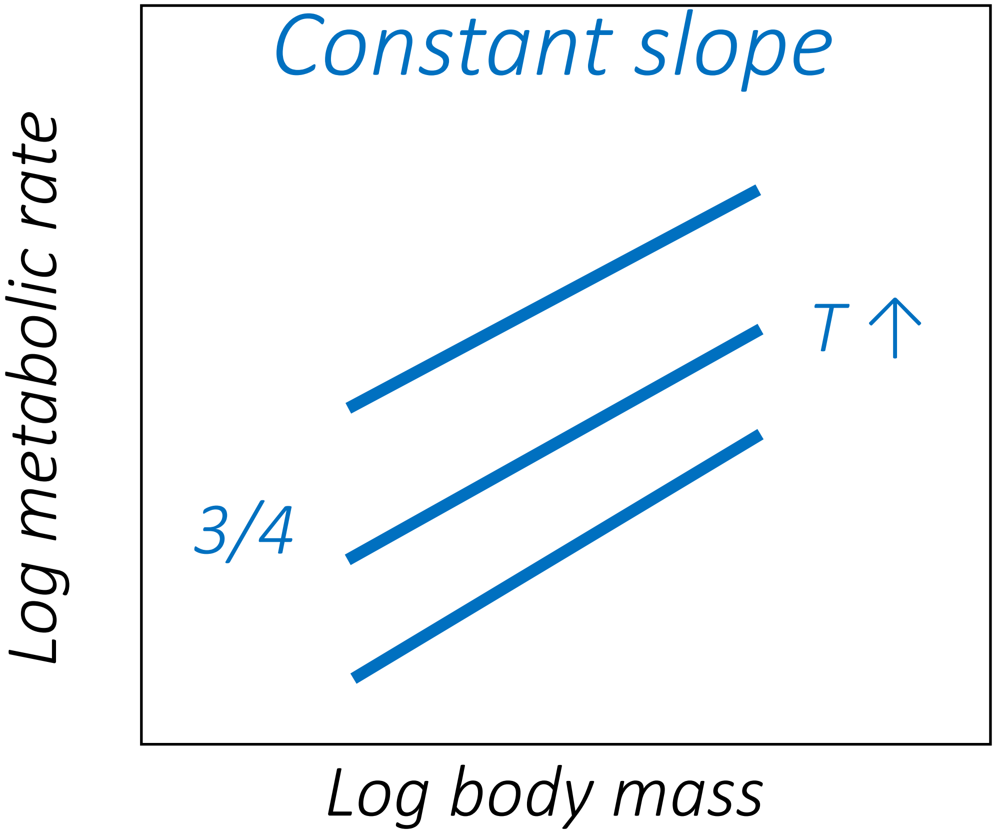
Metabolic Theory of Ecology



(Brown et al. 2004, Ecology)

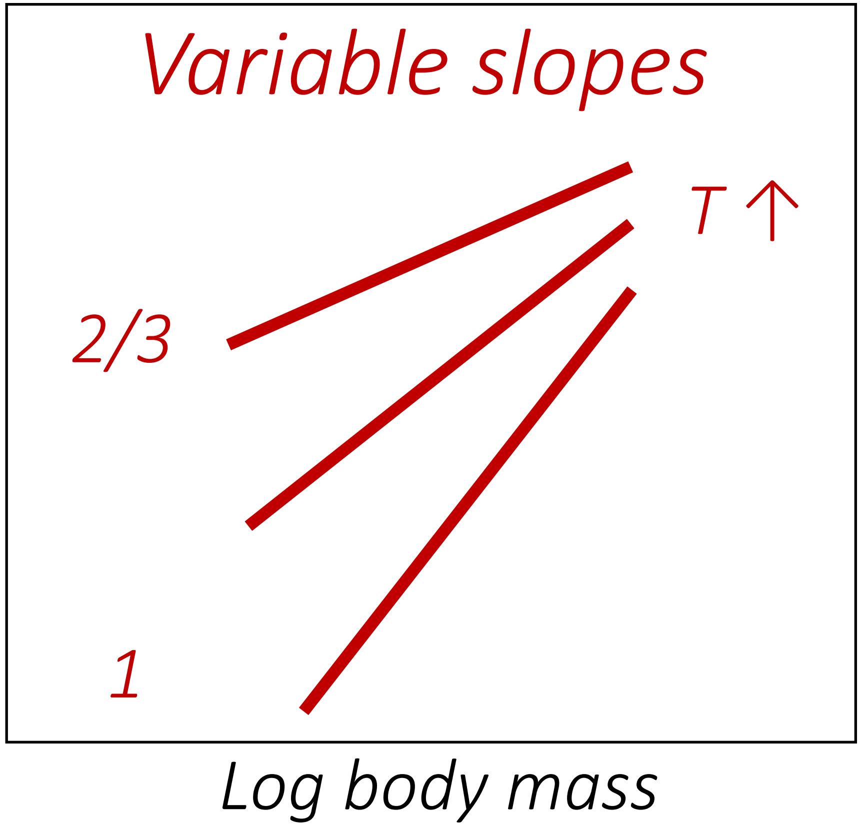
Theoretical background

Metabolic Theory of Ecology

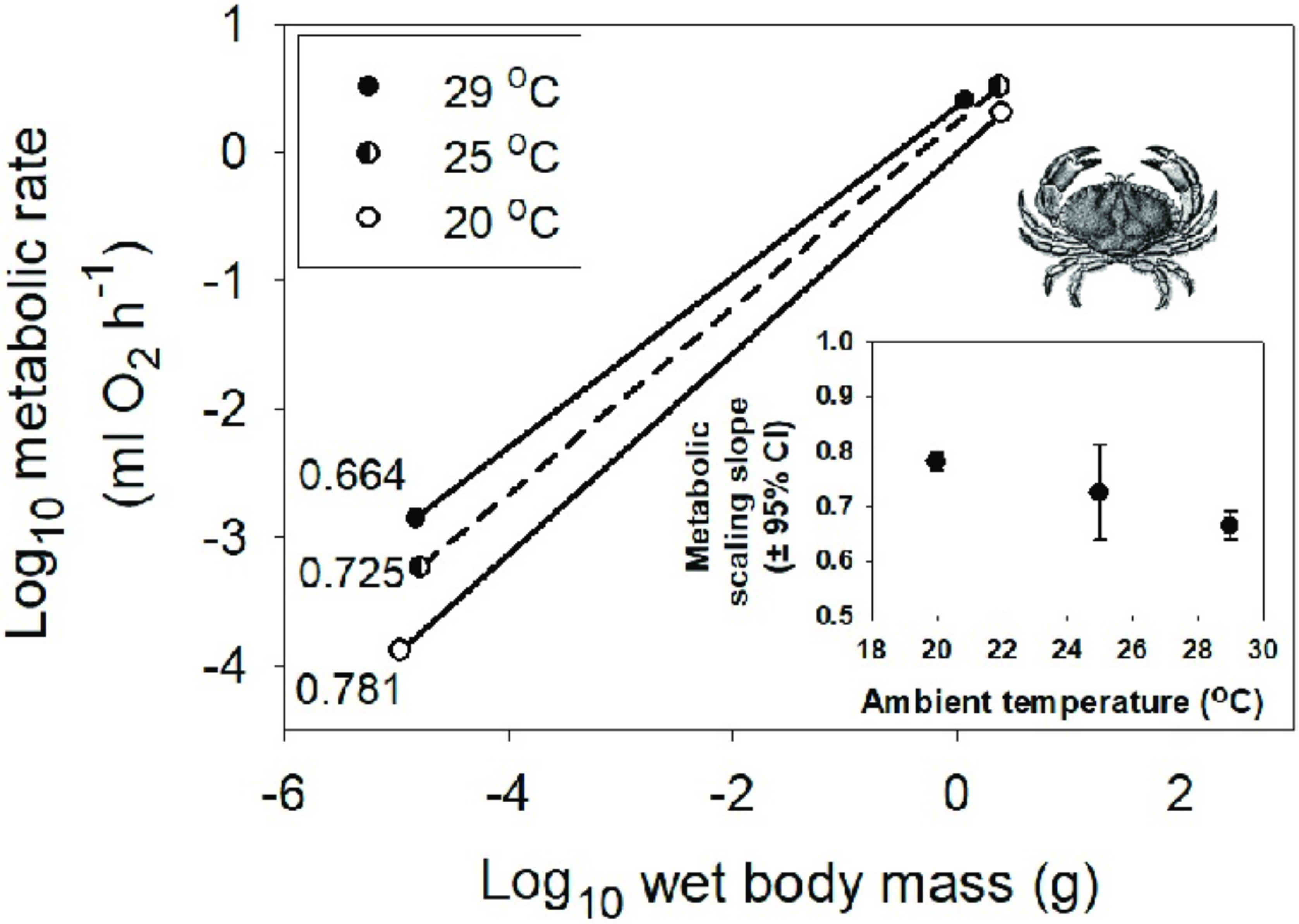


(Brown et al. 2004, Ecology)

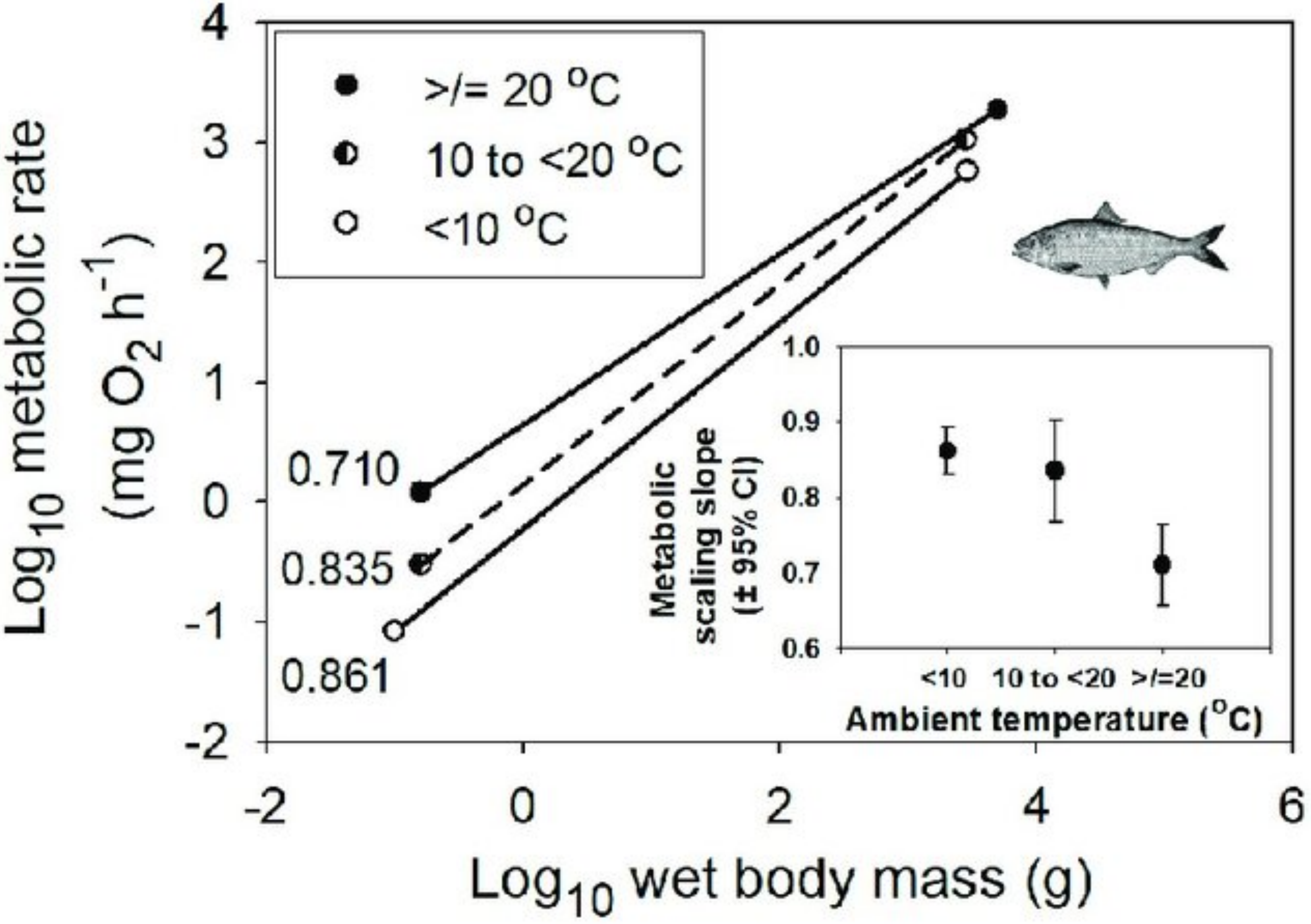
Metabolic-level Boundaries Hypothesis



(Glazier 2005, 2010, Biol. Rev.; 2014, Systems; 2020 JCPB)

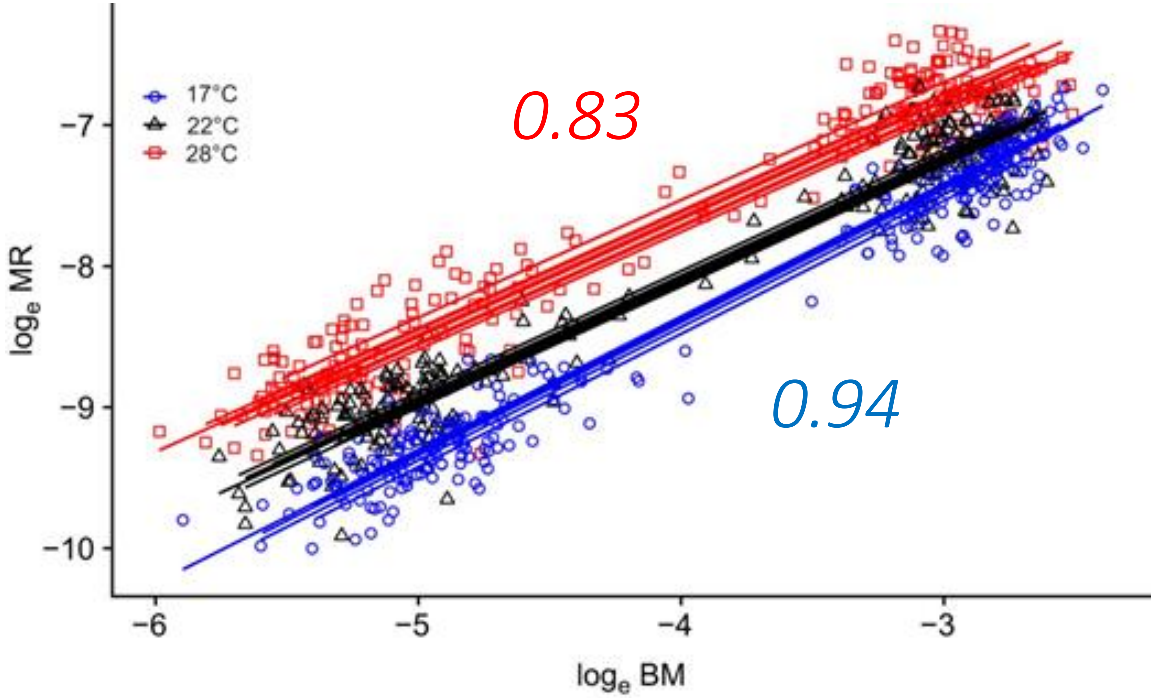


(Glazier 2018, Challenges; data from Ivleva 1980, IRGHH)



(Glazier 2018, Challenges; data from Killen et al. 2010, Ecol. Lett.)

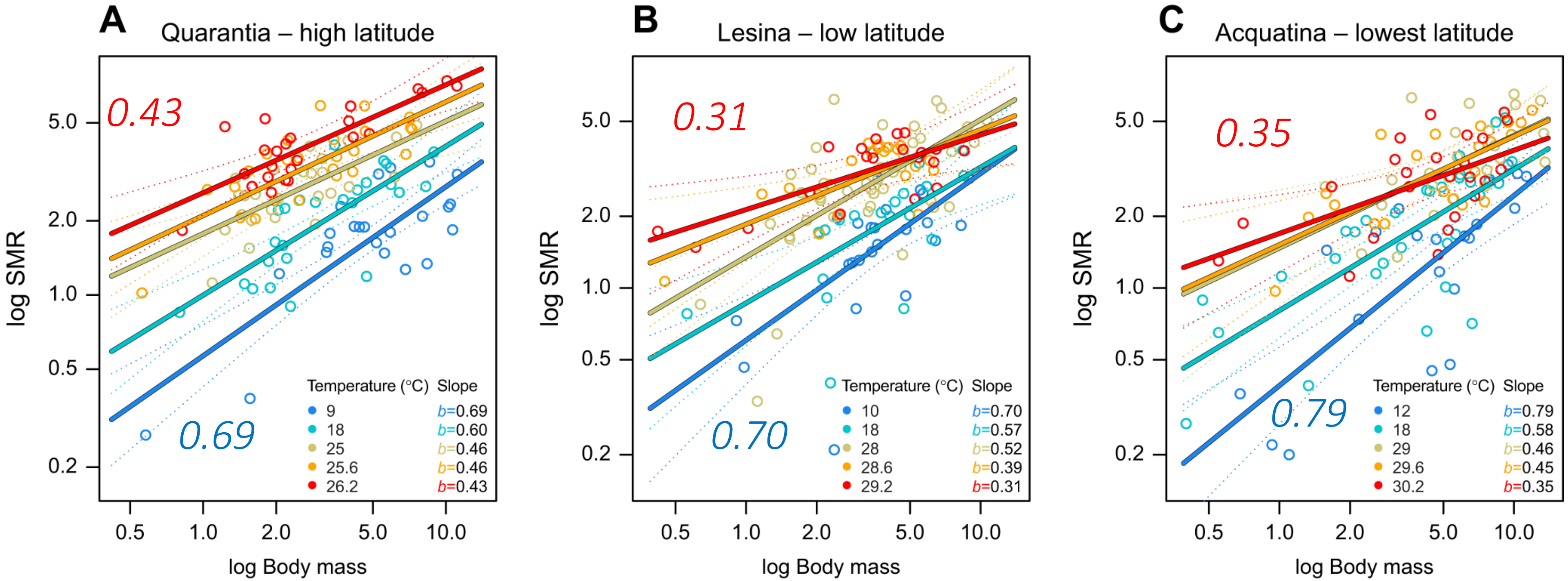
Daphnia



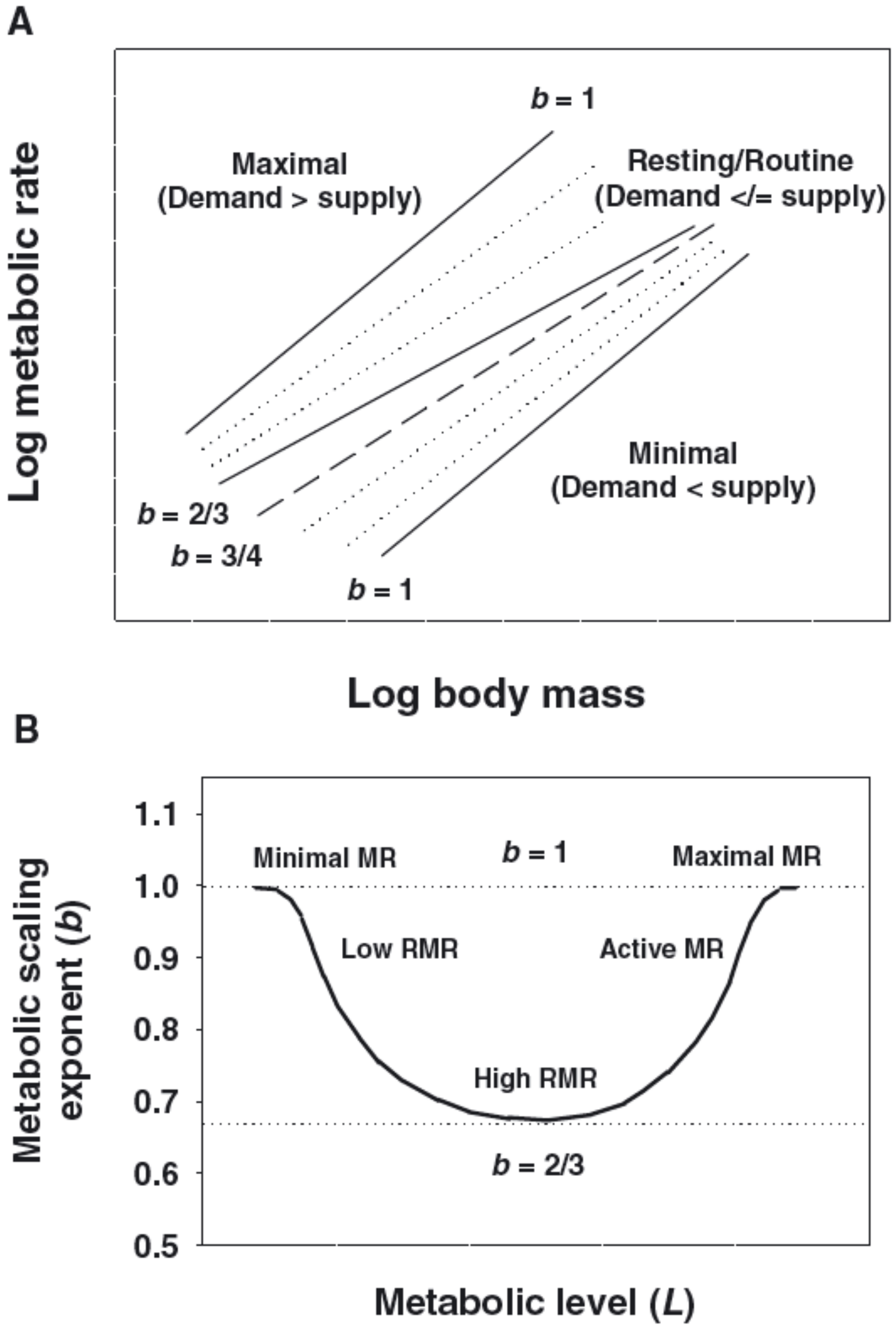
(Fossen et al. 2019, JEB)

(Shokri et al. 2022, JEB)

Gammarus



Effects of behavioral activity

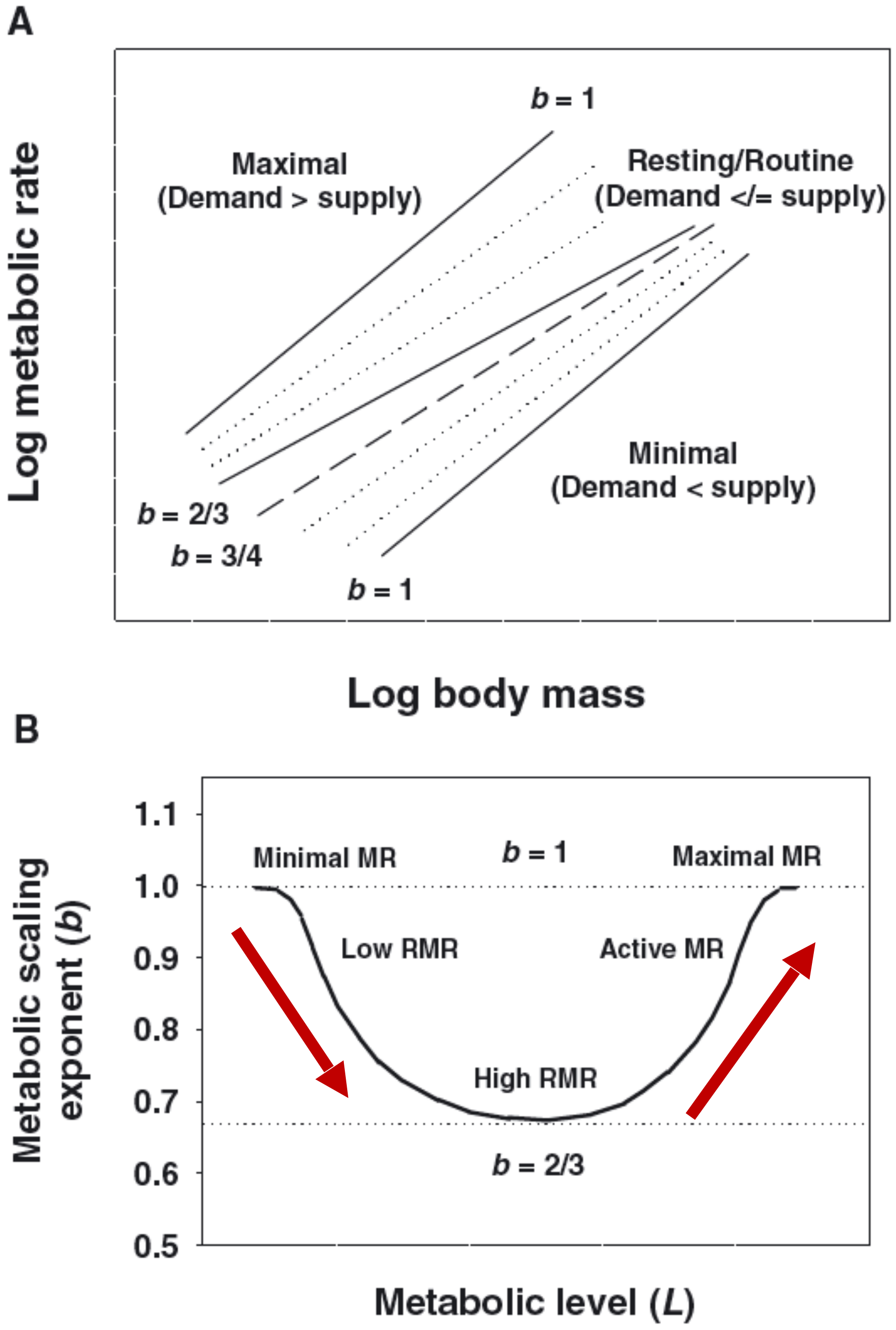


Metabolic-level Boundaries Hypothesis

(Glazier 2010, Biol. Rev.)

Effects of behavioral activity

Scaling slope ↓ as T ↑ in resting state

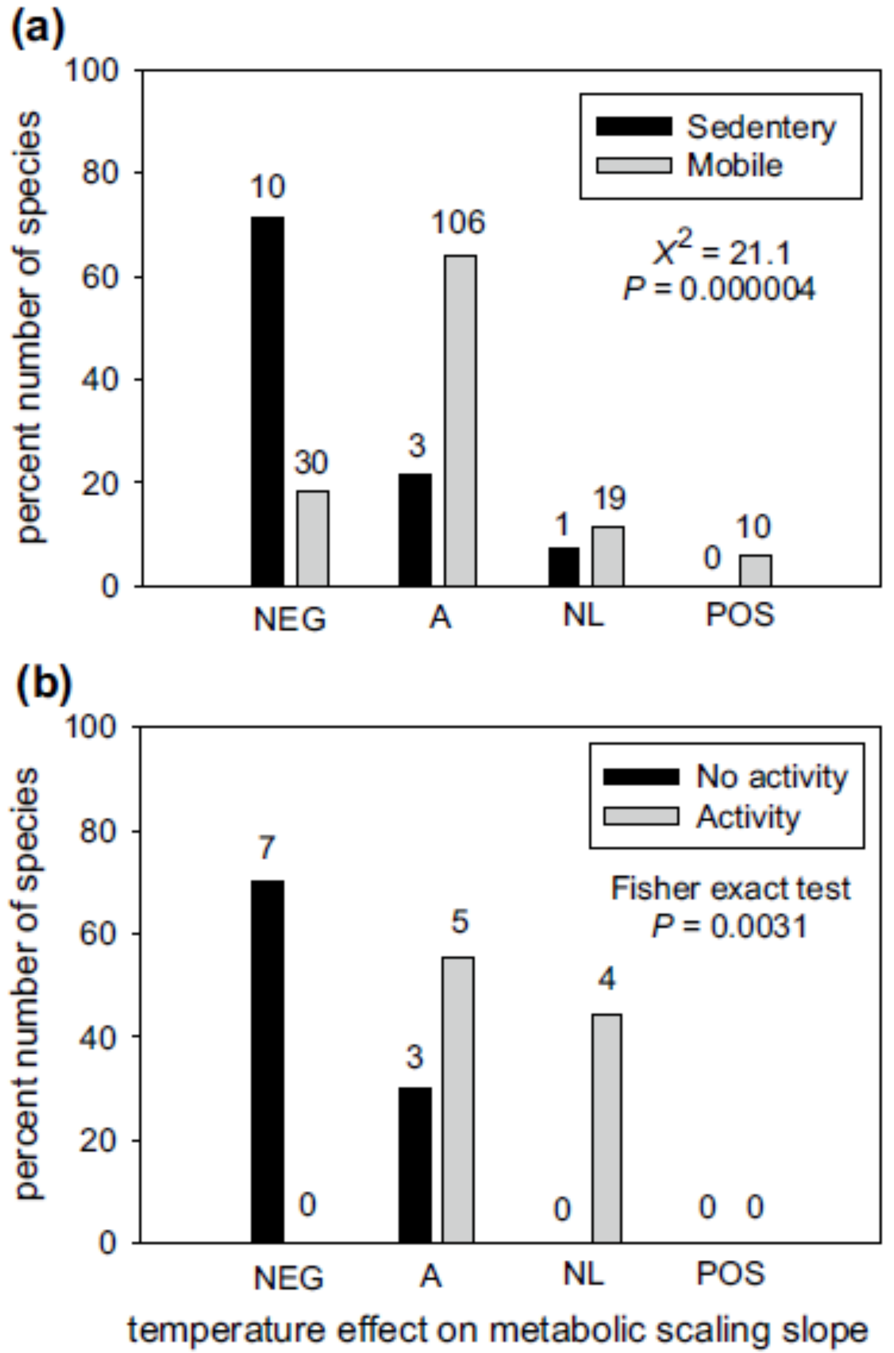


Metabolic-level Boundaries Hypothesis

Scaling slope ↑ if T ↑ increases activity level

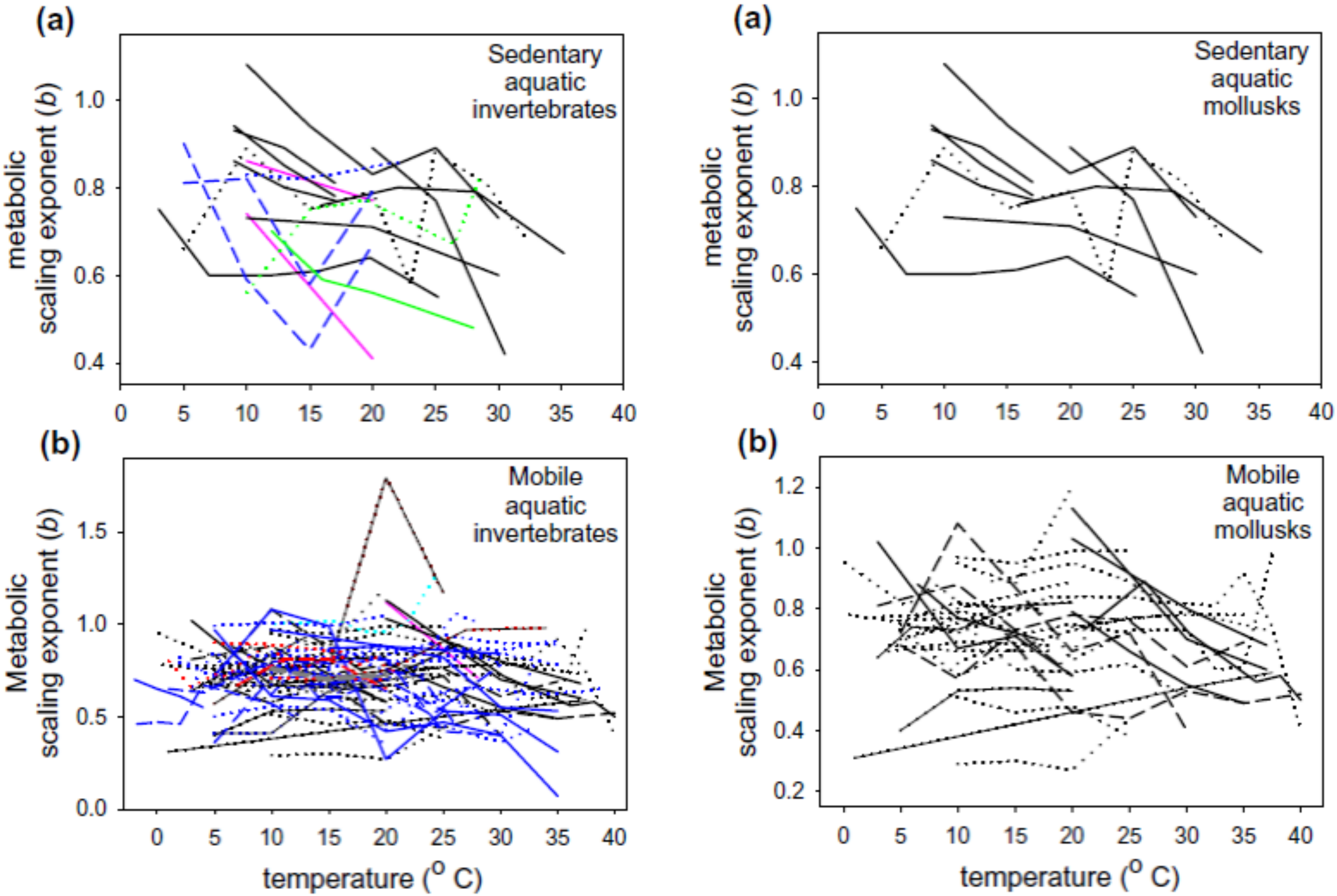
(Glazier 2010, Biol. Rev.)

Scaling slope usually decreases as T ↑ for inactive organisms

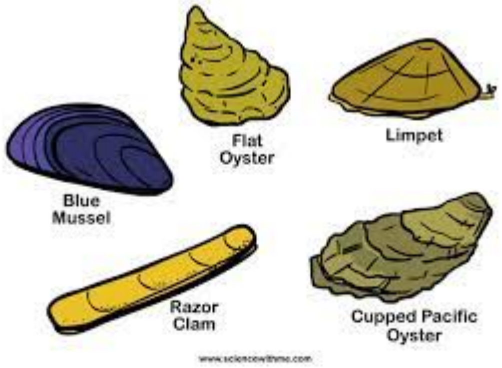


Scaling slope usually doesn't decrease as T ↑ for active organisms

(Glazier 2020, JCPB)

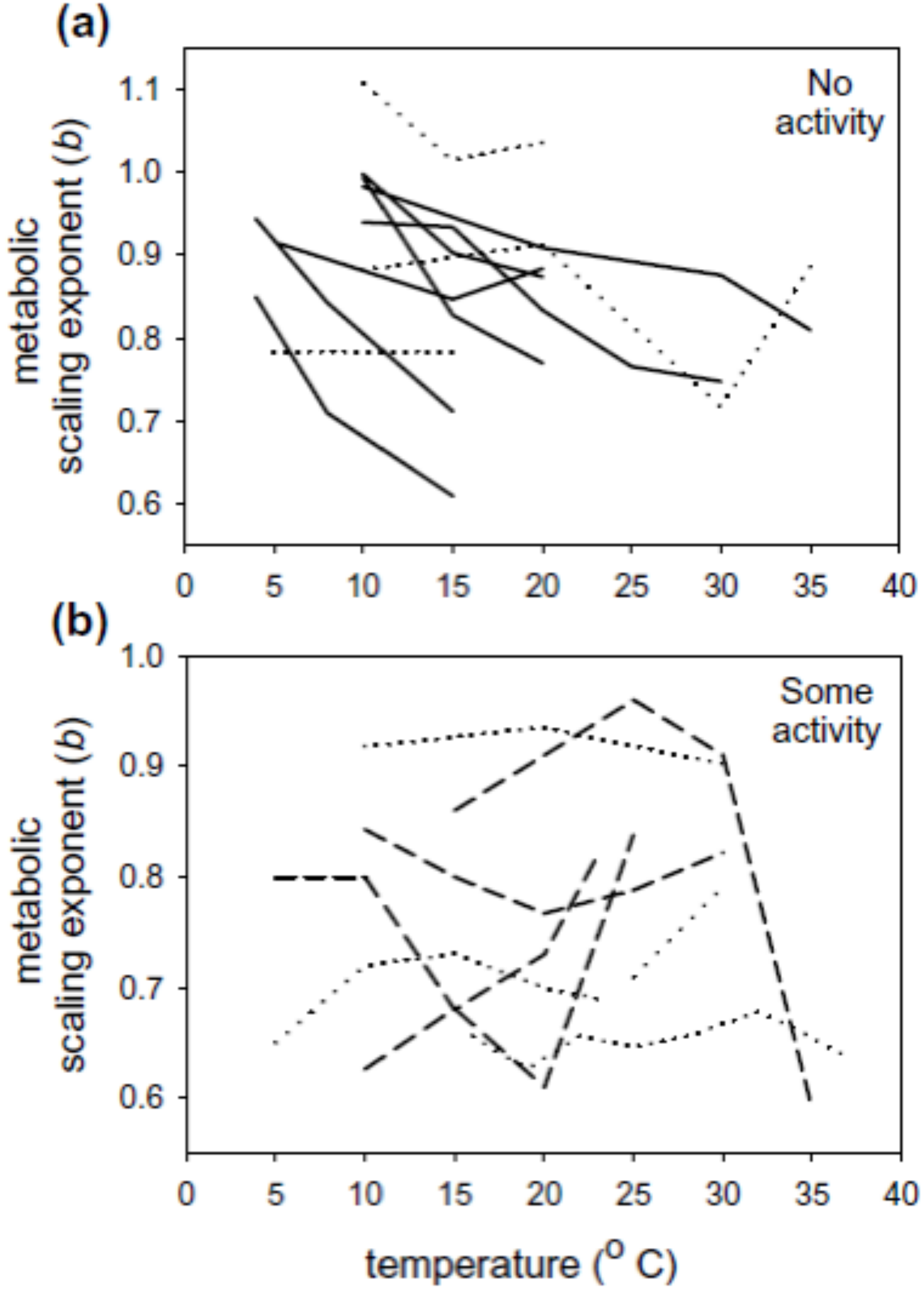


Negative T effects



Mixed T effects

(Glazier 2020, JCPB)



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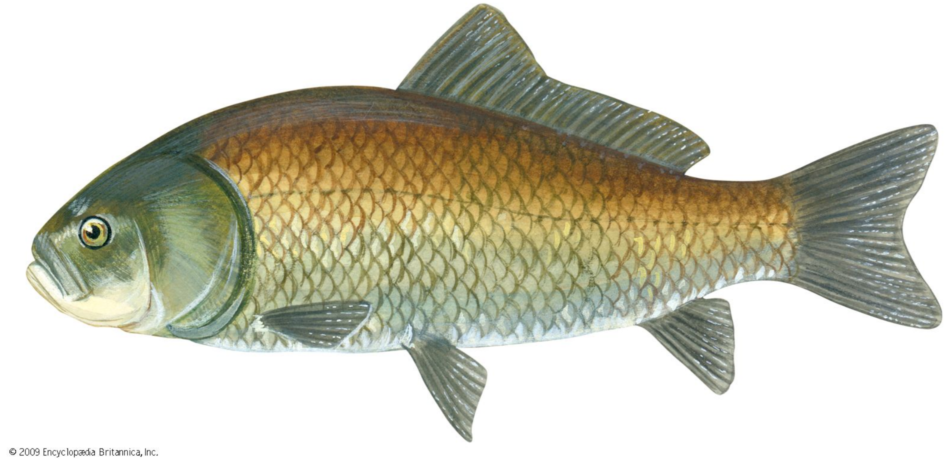
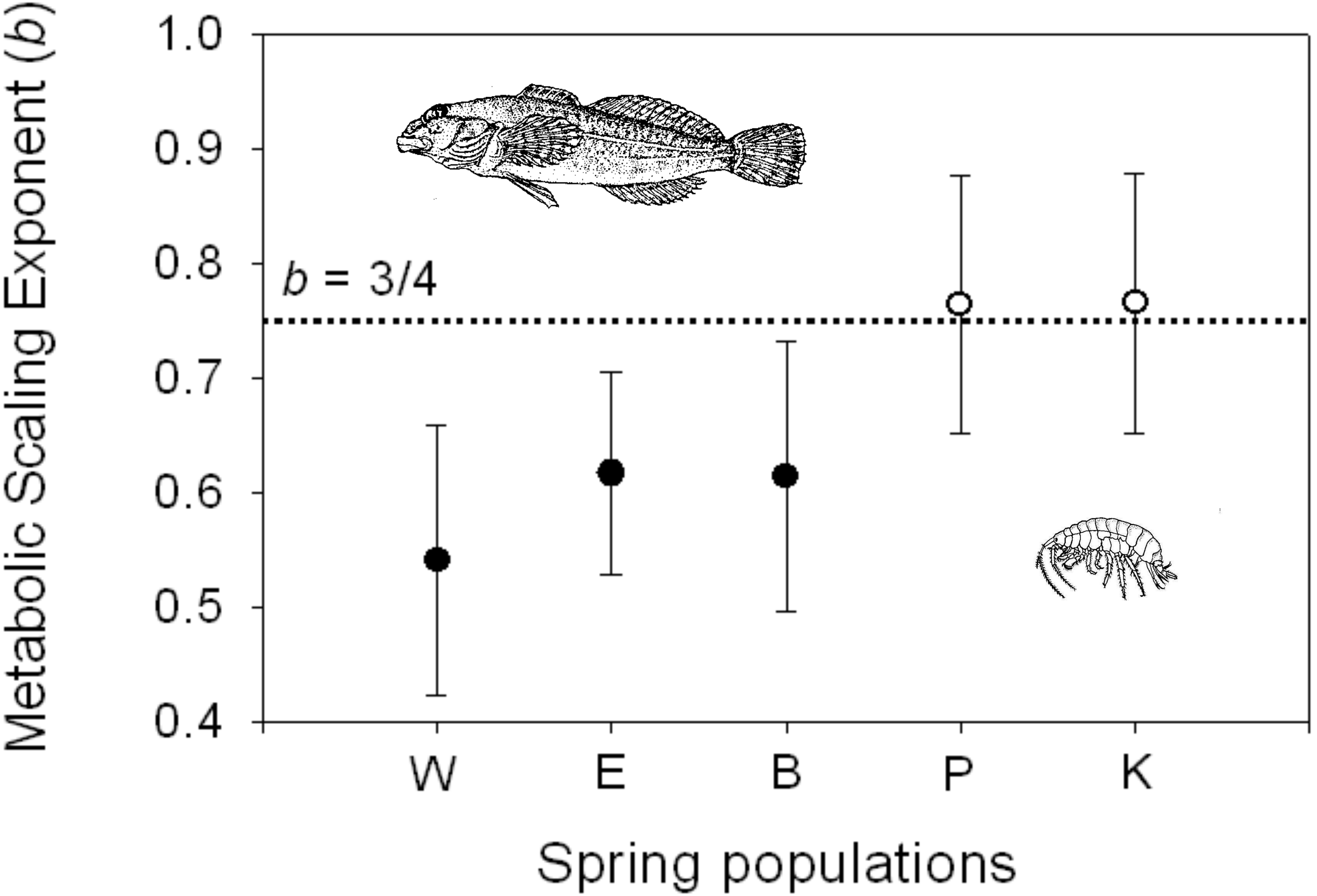


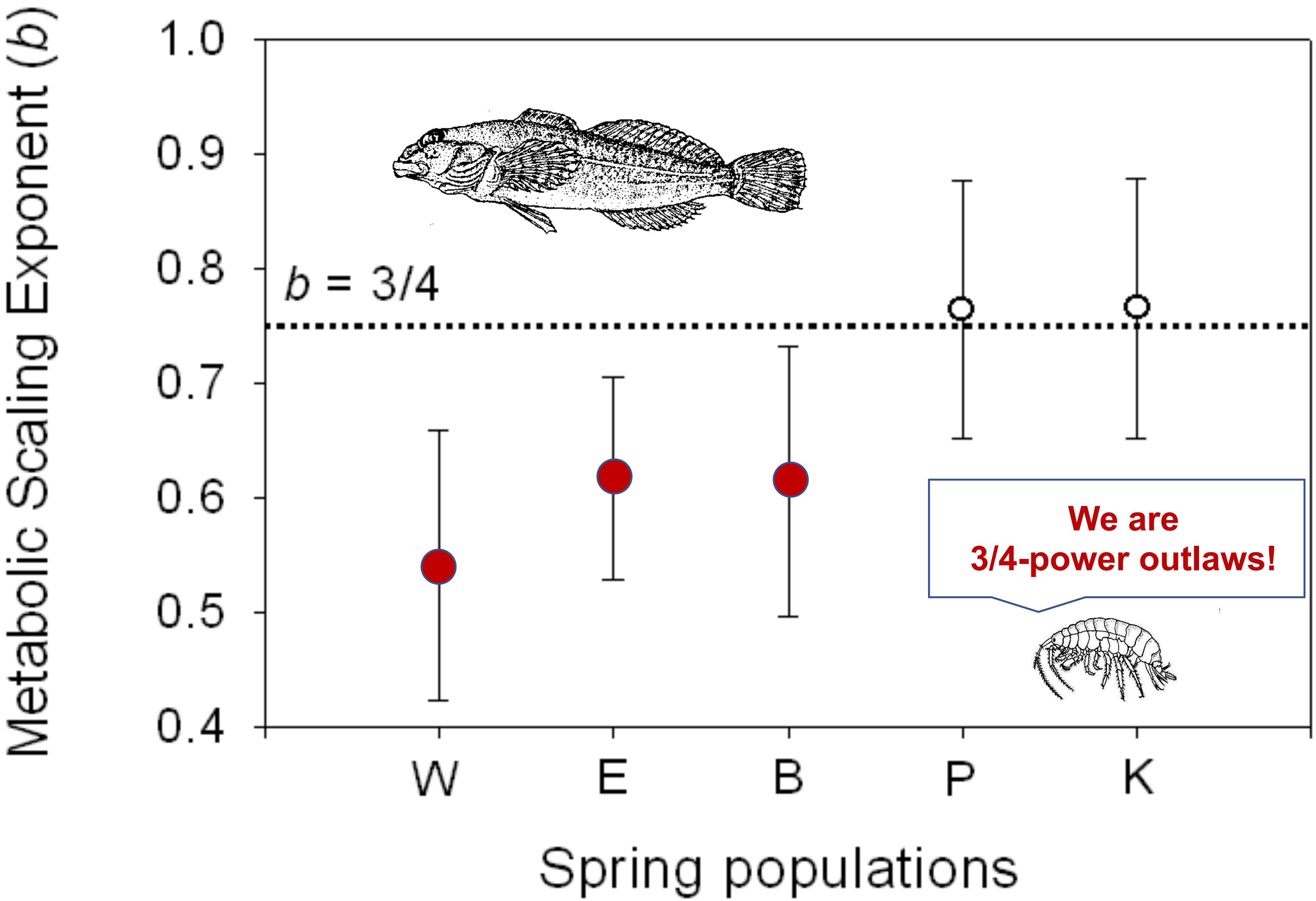
Mixed T effects

(Glazier 2020, JCPB)

Freshwater amphipod

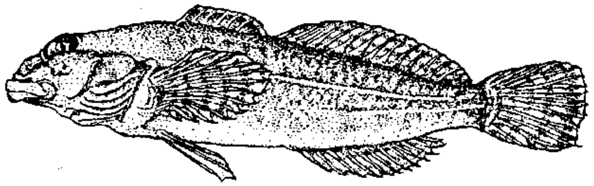
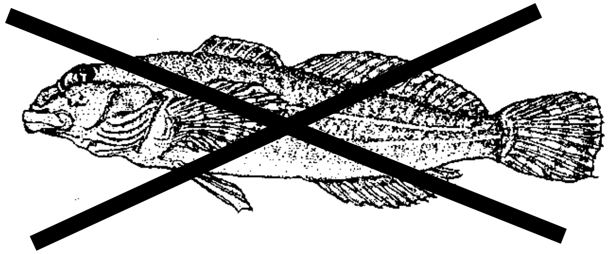


(Glazier et al. 2011. Ecol. Monogr.)



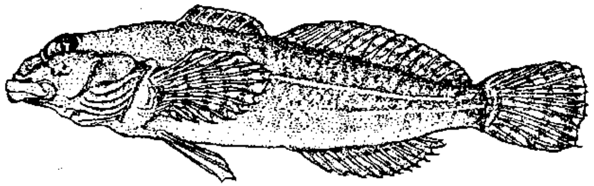
Metabolic Scaling Exponent (b)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
b = 3/4
We are
3/4-power outlaws!
W
E
B
P
K
Spring populations

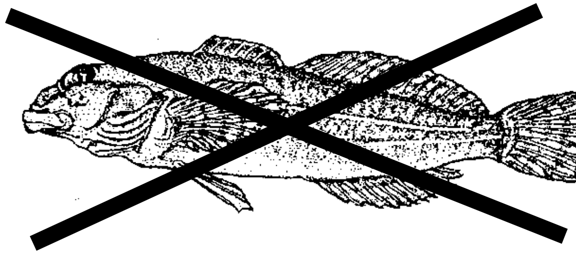
Evolution of parallel allometry of multiple traits in amphipod populations inhabiting freshwater springs with vs. without fish predators

Trait		
	Scaling exponent (b)	
Resting metabolic rate	*0.591*	*0.760*
Growth rate	*0.661*	*0.798*
Gill surface area	*0.620*	*0.743*
Food assimilation rate	*0.623*	*0.796*

(Glazier et al. 2020, Biology)

Evolution of parallel allometry of multiple traits in amphipod populations inhabiting freshwater springs without vs. with fish predators

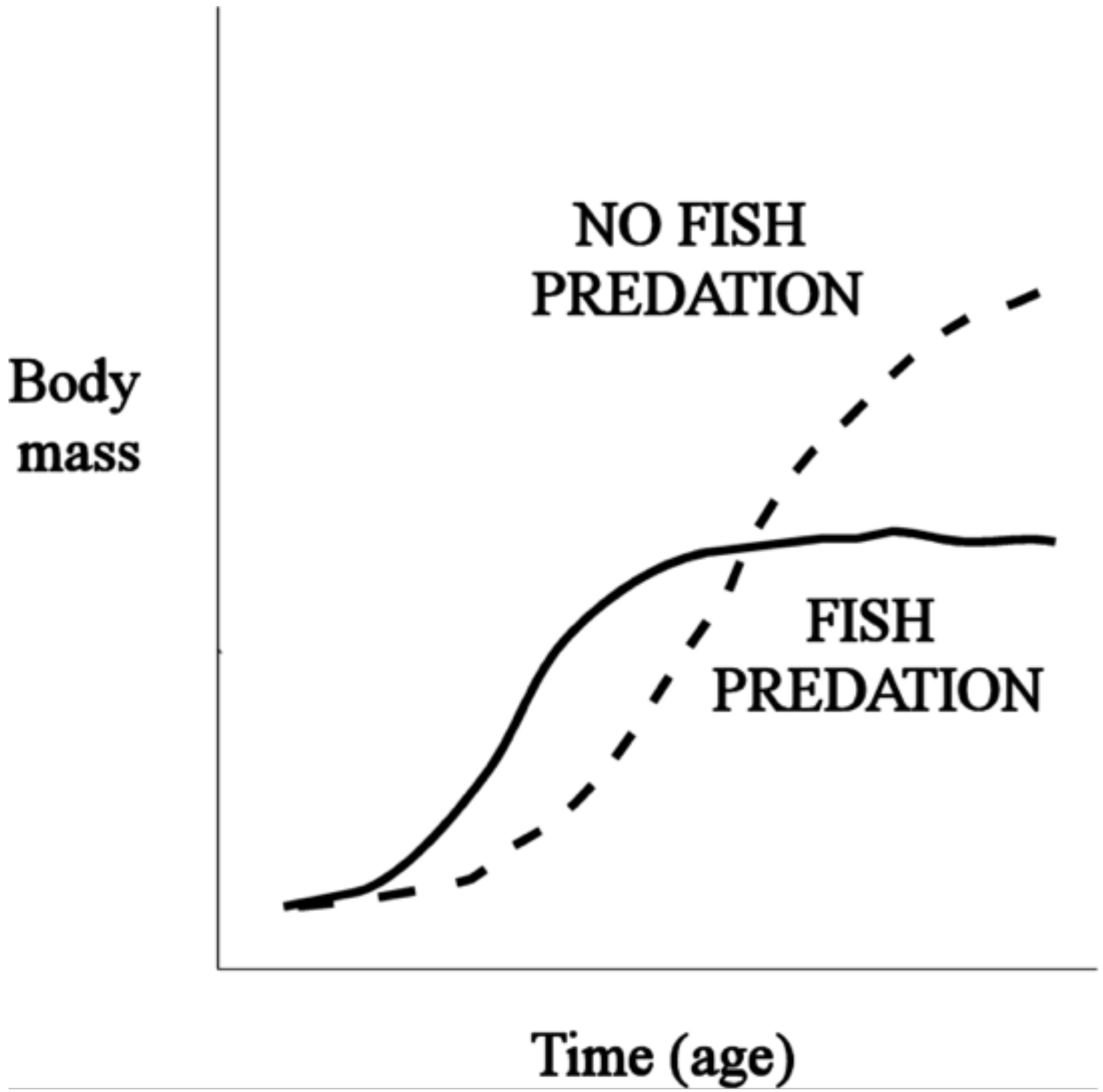


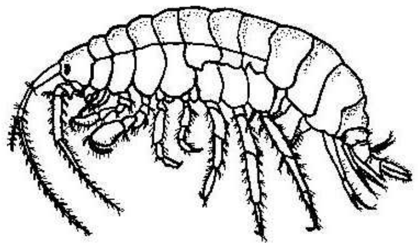


Trait	Scaling exponent (b)		
Resting metabolic rate	0.591	0.760	
Growth rate	0.661	0.798	Growth rate ↑ → b ↑
Gill surface area	0.620	0.743	
Food assimilation rate	0.623	0.796	

(Glazier et al. 2020, Biology)

Growth curves





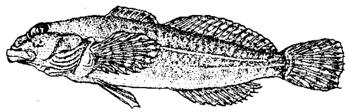
Indeterminate growth

Determinate growth

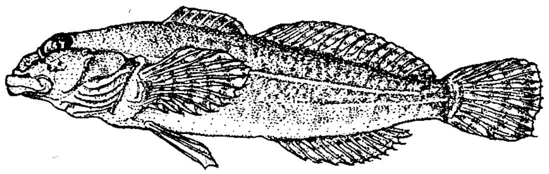
↑

Size-selective predation

MORTALITY

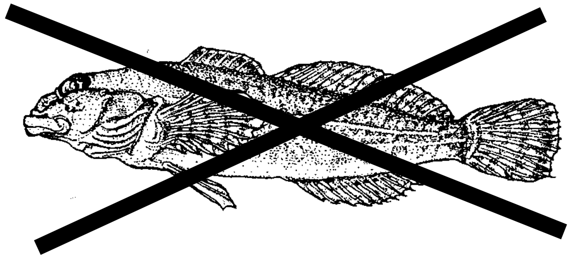


Slope ↓ as T ↑



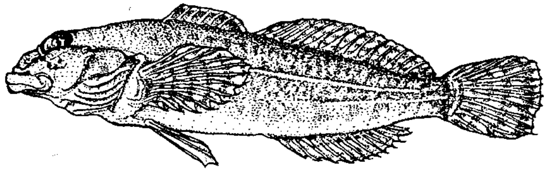
0.88 to 0.52
as T ↑
from 4 to 16^{o}C

Slope ↑ as T ↑

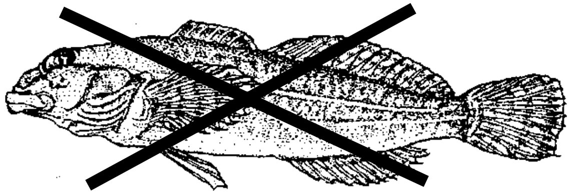


0.57 to 0.93
as T ↑
from 4 to 16^{o}C

(Glazier et al. 2020, JEB)

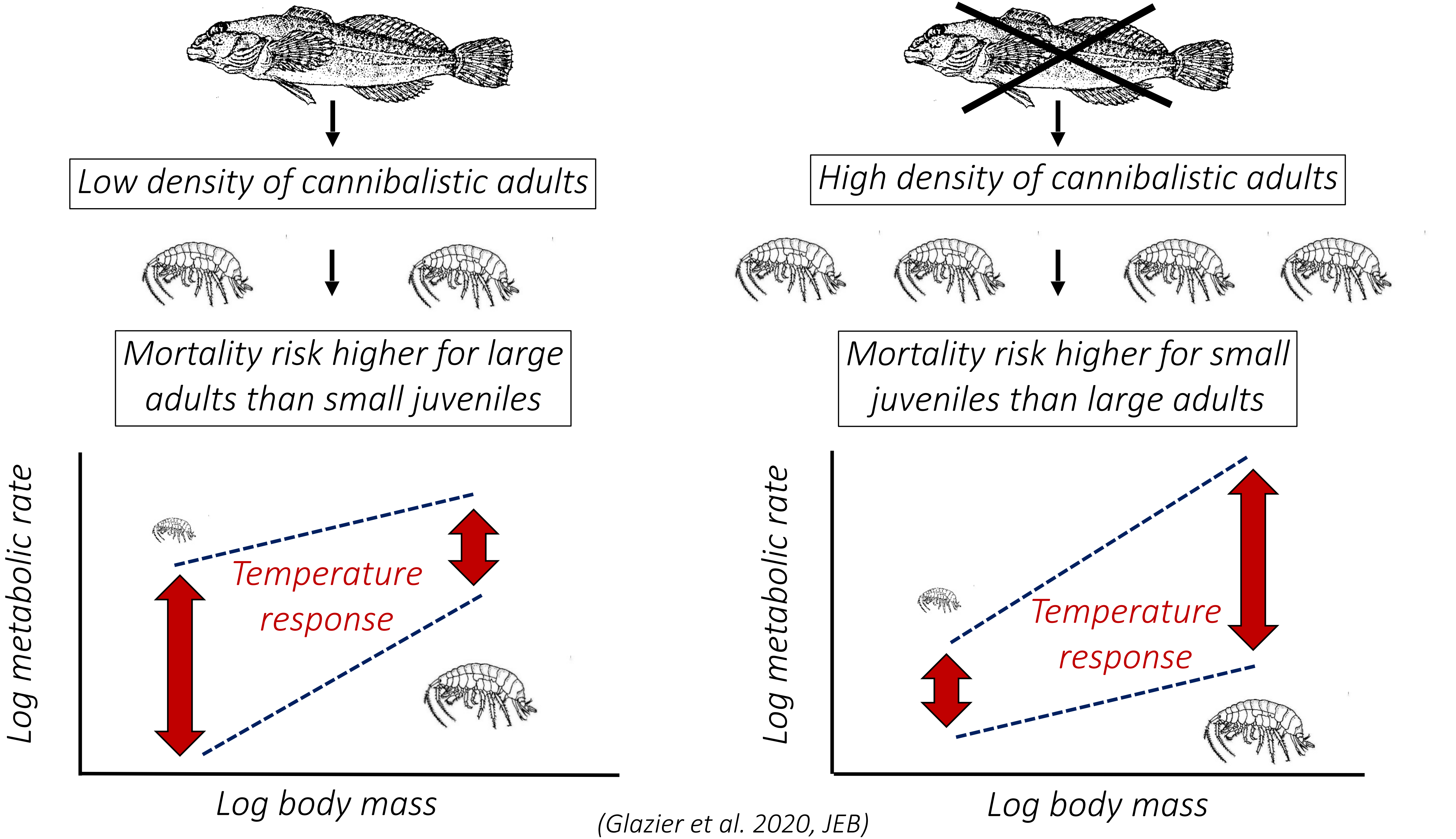


$T \uparrow \rightarrow b \downarrow$



$T \uparrow \rightarrow b \uparrow$

(Glazier et al. 2020, JEB)


Low density of cannibalistic adults
High density of cannibalistic adults
Mortality risk higher for large adults than small juveniles
Mortality risk higher for small juveniles than large adults
Log metabolic rate
Temperature response
Log body mass
Log metabolic rate
Temperature response
Log body mass
(Glazier et al. 2020, JEB)

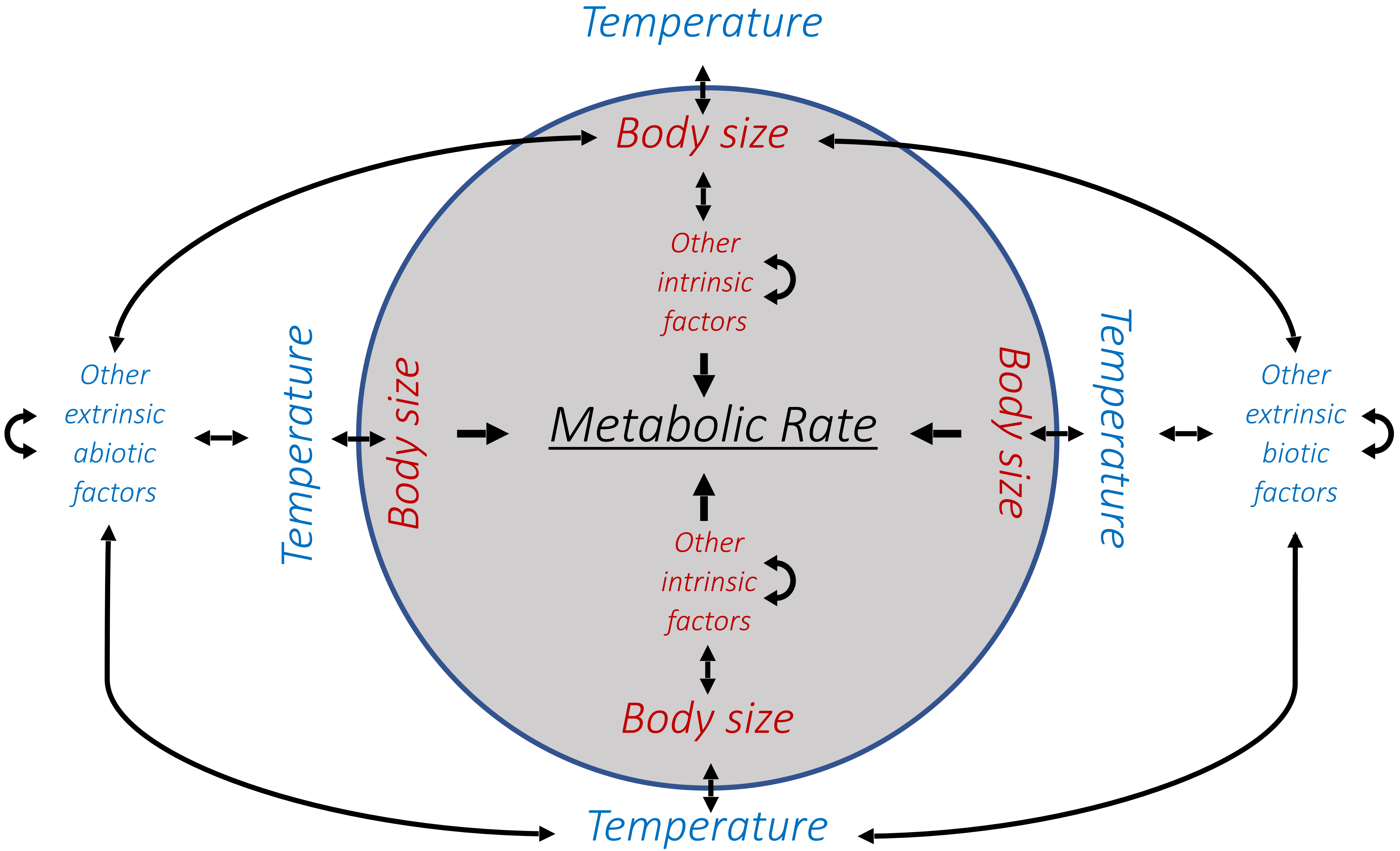
Temperature effects on metabolic rate

Interact with body size
i.e., metabolic scaling slope often changes with T

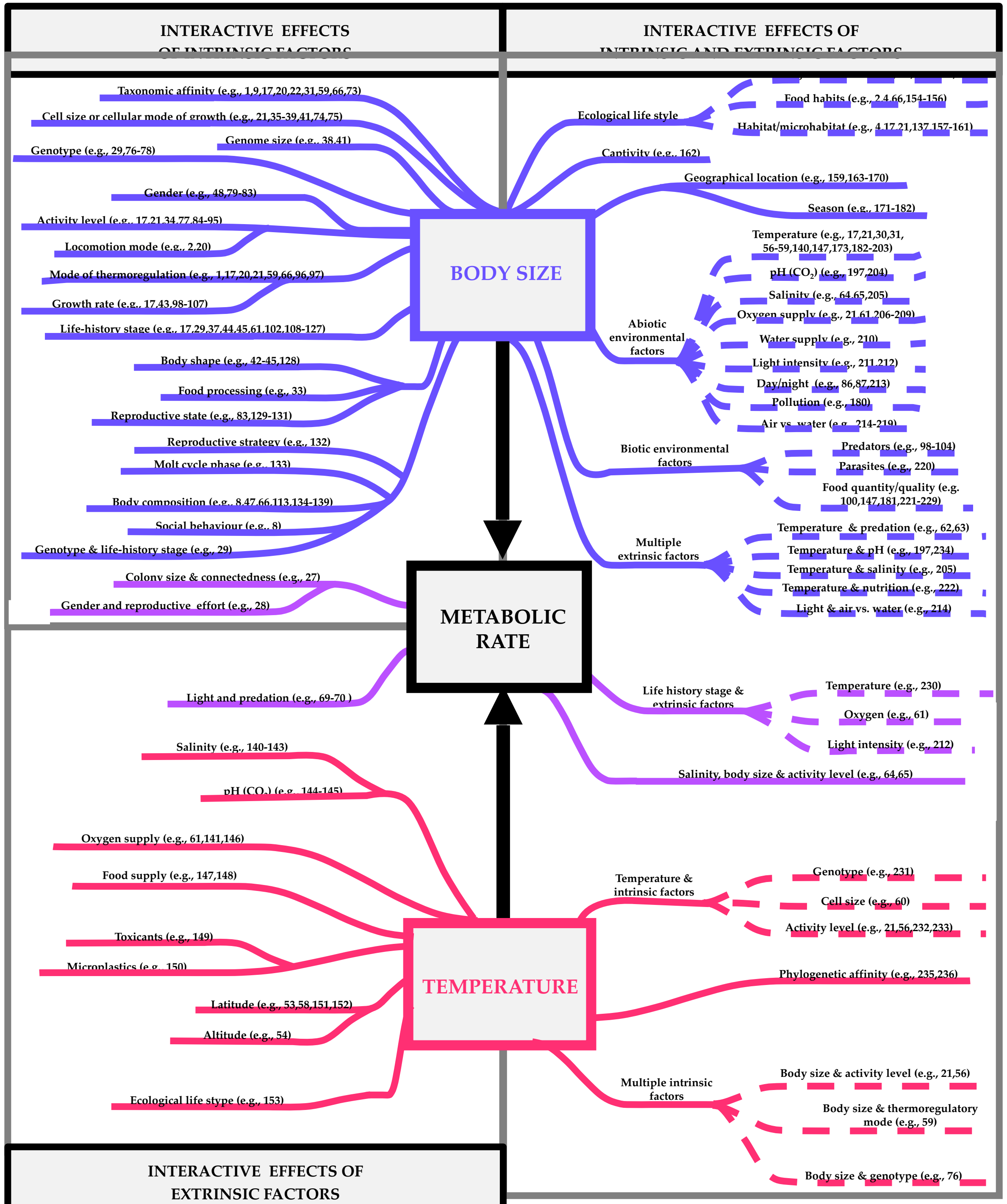
T effects on metabolic scaling, in turn depend
on various intrinsic (e.g., activity level)
& extrinsic factors (predation regime)

CONCLUSION

Effects of climate warming on rates of metabolism
& other metabolically dependent processes of organisms
should be studied in realistic ecological contexts



(Glazier & Gjoni 2024, PTRSB)



(Glazier & Gjoni 2024, PTRSB)

LifeWatch Thematic Service Workshop

Climate Change Impacts on Biodivesity Patterns

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